United States
Department of Agriculture

Forest Service

**Technology &
Development Program**

5100—Fire Management
February 2006
0651 1803-SDTDC

Interagency Retardant Base Planning Guide

February 2006

INTERAGENCY RETARDANT BASE PLANNING GUIDE

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Prepared by:
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February 2006

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This memorial is placed at the Moses Lake Tanker Base in the state of Washington. It is a tribute to "Ted" J. Swartz, whose knowledge and commitment to the Air Tanker Retardant Base program produced many of the design and construction methods discussed in this Guide.

Foreword

This Interagency Retardant Base Planning Guide has been developed and published by the NWCG Fire Equipment Working Team (FEWT) to identify interagency minimum planning criteria when establishing or modifying a retardant base facility.

A subcommittee was formed in 1978 and development and preparation of this Guide was accomplished in 1979, with the first 4 editions being published as the Airtanker Base Planning Guide in 1980, 1985, 1990, and 1995 respectively. The NWCG FEWT subcommittee for this 5th edition consisted of:

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Table of Contents

Figures

INTRODUCTION

This National Wildfire Coordinating Group (NWCG) publication is an interagency guide to help achieve proper planning of a retardant base. This guide includes the planning and setup of permanent, temporary, and portable, fixed and rotor-wing retardant air bases. The intent is to provide interagency minimum planning criteria for retardant bases to ensure a safe, cost effective and efficient operation. This guide is for the use of all wildfire agencies to assist in the planning of new bases or for modification or expansion of existing bases.

No two airtanker bases are alike, but standardization of components is desirable. In many cases, such bases have been developed by making use of surplus materials and have undergone continual modification and growth as needs change. Fire chemicals and systems to mix, measure, and monitor them are continually being improved. This often requires changes at existing retardant bases. It is important to continue to treat washdown water and waste retardant material in compliance with all environmental laws and regulations. These requirements are becoming more stringent as time goes by, necessitating changes at these bases. Other aerial operations are often staged at these bases including helitack, single engine airtanker (SEAT), modular airborne fire fighting system (MAFFS), helitanker, and transportation of cargo and personnel.

Each base should have a development plan (including improvement phasing) that guides the construction, modifications, and expansion that is required to maintain a safe, efficient and effective aerial fire retardant operation. The components of such a plan and the considerations for developing a plan are included in this guide. For reference, a glossary of terms and the sources for the material used in the guide are provided. Information on airtanker base operations is available in the Interagency Airtanker Base Operations Guide (1).

BASE DEVELOPMENT PLAN

When establishing a new permanent retardant base or making improvements to an old base, an analysis of the base and its components is needed. A planning team should evaluate the potential sites or present site to determine how well the site and existing facilities meet the needs for safety, security, environmental protection, mission support, and effective and efficient delivery of retardants for fire suppression purposes. The team should include an aviation specialist, a qualified engineer, and a contracting officer. Preliminary planning for the new base or base modification should be accomplished prior to the start of any design or construction phase. Many decisions must be made in this preliminary phase. These decisions will determine the type of airtanker base most suitable for a specific location and set of conditions. The preliminary planning effort should produce a base development plan. This plan helps to clearly define the type of installation required and ensure a cost effective design and construction.

Figure 1—Aerial view of typical retardant base (Klamath Falls, OR).

The base development plan should define the appropriate site, the facilities to be retained, the facilities to be disposed of, and the facilities to be constructed or otherwise acquired. Development decisions such as phasing and funding should be included.

To the extent practical the potential location of temporary bases should be identified. The managing agency should prepare a base development plan for use when the base is activated.

Purpose and Content

A base development plan should be prepared for each existing or proposed retardant base. It should provide the guidelines and plans for development of any new base and for improvement of any existing base. The plan should include a design prospectus, a concept plan, an environmental document, and a funding plan that includes phasing strategies.

The design prospectus will provide all the design criteria that are needed to assist engineers in designing a cost-efficient base. It will include information about necessary facilities, site amenities, and utilities essential to the official who negotiates the land acquisition (lease or purchase) for the base. The prospectus will include all information on current use, future use, site development implications, and government agencies that pertain to the selected site. Project scheduling, funding, and phasing should also be included.

The concept plan (preliminary site layout) will help the designer ensure that all needed components are included in the final design and that spatial orientation is efficient for base operations. The concept plan should show the relationships of runways and taxiways and should show at least one preliminary layout plan that accommodates all required components on the selected site. Alternative layouts are preferred at the preliminary stage. The concept plan is essential in negotiation for acquisition of a suitable site and establishment of lease or property boundaries.

Archeological and biological site surveys and analysis should be performed on all potential sites prior to final site selection. Appropriate National Environmental Protection Act (NEPA) documentation must be prepared and approved prior to project implementation. This step may prevent a costly stoppage of the project in a later phase.

Based on the prospectus and concept plan, funding needs should be determined and strategies developed for logical, cost-efficient sequencing of development, where possible. Consideration should be given to phased construction alternatives that will facilitate funding a series of projects to complete the base construction or improvements.

For temporary bases, the plan should be written into one document that can be used to acquire the site and install temporary facilities when the need arises.

Considerations

When preparing a development plan for a retardant base, certain preliminary assumptions and general requirements must be determined. The bases' intended mission will define some of these assumptions and requirements. The base development plan should include the potential for all reasonable future uses.

No single plan will be applicable to all situations since bases can be constructed at airports having varying available space and aircraft runway sizes. All new plans and modifications should maximize the efficiency and output and minimize the response time and total cost.

Retardant base planners must work closely with agency procurement authority, airport administration and advisory boards, area planning commissions, boards of supervisors, city councils and such to ensure that the agency use of the facilities is compatible and can be continued. The most important consideration is the compatibility of the intended use as a retardant base with the airport master plan. Review all applicable municipal, county, and State zoning laws for chemical handling, mixing and/or production plants, facilities, utilities, and access roads.

Planners must also work closely with forest or regional disaster preparedness planners to identify contingency activities that might be located at the base in case of terrorist attack, flood, earthquake, or other disasters (evacuation, search and rescue, resupply, equipment or personnel staging, medical triage, and so forth). Planning should also define contingency circumstances that might affect the base such as unavailability of adjacent retardant bases, shifts in aircraft type or availability, and staging of resources at the base.

Planners should also review prefire plans that identify the location of caches, crew, equipment positioning, and other activities that might be shifted to the site when the base is constructed or upgraded. Availability of dependable personnel for operation of the base must be examined.

Current use

The first consideration in airtanker base planning is the required response time and current use of aircraft for the lands to be protected. Just as important is the current use of airports within the required response time. Identify current airtanker fleet and contracts of adjoining bases to determine the type, size, and number of aircraft expected to operate out of the retardant base. Determine the use of the base by MAFFS aircraft, SEAT, cargo or passenger loading aircraft; smokejumper or other fixed wing operations, helitankers, and helitack or other rotor-wing aircraft use.

Evaluate peak loading requirements based on the past 10- to 20-year history.

Figure 2—Existing retardant base with user conflicts.

Determine the current land use patterns around the site and around the airport.

An inventory of existing and available equipment helps in planning modification and expansion. Age, condition, and reliability must be determining factors when considering reuse of existing equipment and facilities.

Future use

The analysis must consider what the future use of the base might be. Sites used for retardant bases are often used for many aviation and fire suppression related activities.

Identify all aircraft expected to use the base. Where possible, planning large bases should include accommodation for MAFFS aircraft. Identify other agency mission requirements for the base. Consideration for cargo and passenger transport, SEAT operations, helitanker operations, helitack, and other single- and multi-engine mission aircraft may need to be included. Evaluate peak loading requirements considering the cost benefit of other base use.

Land use patterns around the site and around the airport should be considered to determine that they are (and will continue to be) compatible

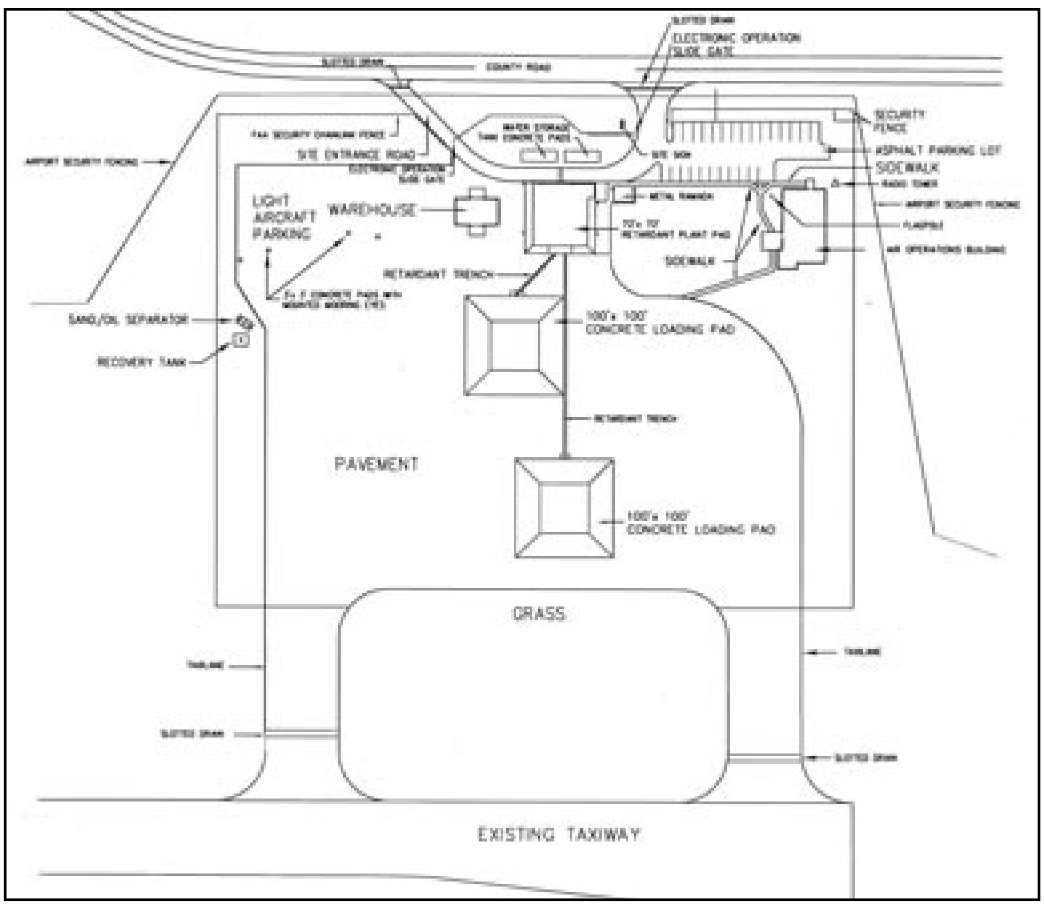

Figure 3—Typical retardant base site layout (based on Durango, CO).

with the planned air operations. The airport development plan as well as city or county land use plans and planning departments should be consulted.

Site requirements

Based on the current and future uses, define what must be included in site development.

Exclusive use areas for aircraft taxi, parking, and loading are usually provided. Provisions are normally needed for “landside” functional areas such as operations, administration, retardant mixing and storage, and/or passenger/cargo holding and processing.

Past use of each site should be investigated for possible hazardous material (HAZMAT) contamination such as pesticide operations, other chemical spillage, or fuel and oil saturation. Soil sampling of each site must be performed.

Site size and shape—Once the site use is determined, the facilities required to support that use can be determined utilizing later sections of this guide. The approximate space requirements of each component can be determined and preliminary site layouts prepared to ensure that adequate space is available for the proposed base or proposed improvements. Each site to be considered should be investigated to determine the amount of usable area for each function. Preliminary site layout may be required for each potential site to determine that adequate room is available.

A permanent retardant base typically requires 7 to 20 acres to allow for airtankers, leadplanes, a retardant mix plant, an operations building, and a warehouse. Additional space, services, and utilities will be required if SEAT operations, rotor-wing operations, passenger and cargo loading, or other operations are to be located on the site.

Aircraft traffic flow—Airfield or “airside” facilities are located on the portion of the airport (or heliport) where aircraft operations are carried out. They consist principally of areas for aircraft, such as takeoff, landing, taxiing, parking, loading, service, and so forth. These facilities will limit the aircraft size, type, and numbers used for the intended air base operations. A survey must be conducted of the existing and available facilities before any retardant base layout can be started.

If the facilities do not or cannot be made to accommodate the aircraft needs for the proposed air base, you will have to restrict aircraft usage or locate a more suitable airfield. Consider all possible requirements for future expansion.

Priority must be given to: runway, taxiway and ramp bearing strengths, runway length, available ramp space, and the geographic location.

Consider possible impact on location with respect to prevailing wind, taxi distances, access, and availability. Day/night approach facilities also may be a consideration.

Generally a through flow of aircraft is desirable in the ramp area. Determine that adequate separation of light aircraft, heavy airtankers, passenger and cargo loading aircraft, helitankers, and other rotor wing aircraft can be accommodated.

Airspace. Approach and departure airspace consists of imaginary surfaces that define the obstacle free zones for approach, transition, and departure. Approach and departure airspace have a direct effect on types of aircraft that can be operated from the airfield (11). (See figure 4.)

On an established airport, these restrictions will usually be included in the airport master plan. Other sources of reference include FAA Advisory Circulars and Interagency Guidance (6,10, and 11).

Runways and taxiways. Runways and taxiways are normally the responsibility of the airport and must conform to current FAA guidelines for geometric configuration and load bearing capacity (21). The configuration and capacity should be determined and compared to the requirements for the aircraft that will use the base. Often, taxiways are designed for smaller and lighter aircraft than planned for at the base. Special agreements must be negotiated to upgrade runways or taxiways that will not be leased to the agency. Runway and taxiway use is generally provided for under a document called the Airport Runway Use Agreement, which covers such items as use of overweight aircraft, inspection and repair of damages, cleanup of spillage, and payment of landing and temporary offsite aircraft parking fees.

Information on constructed runways can be found in the U.S. Department of Commerce,

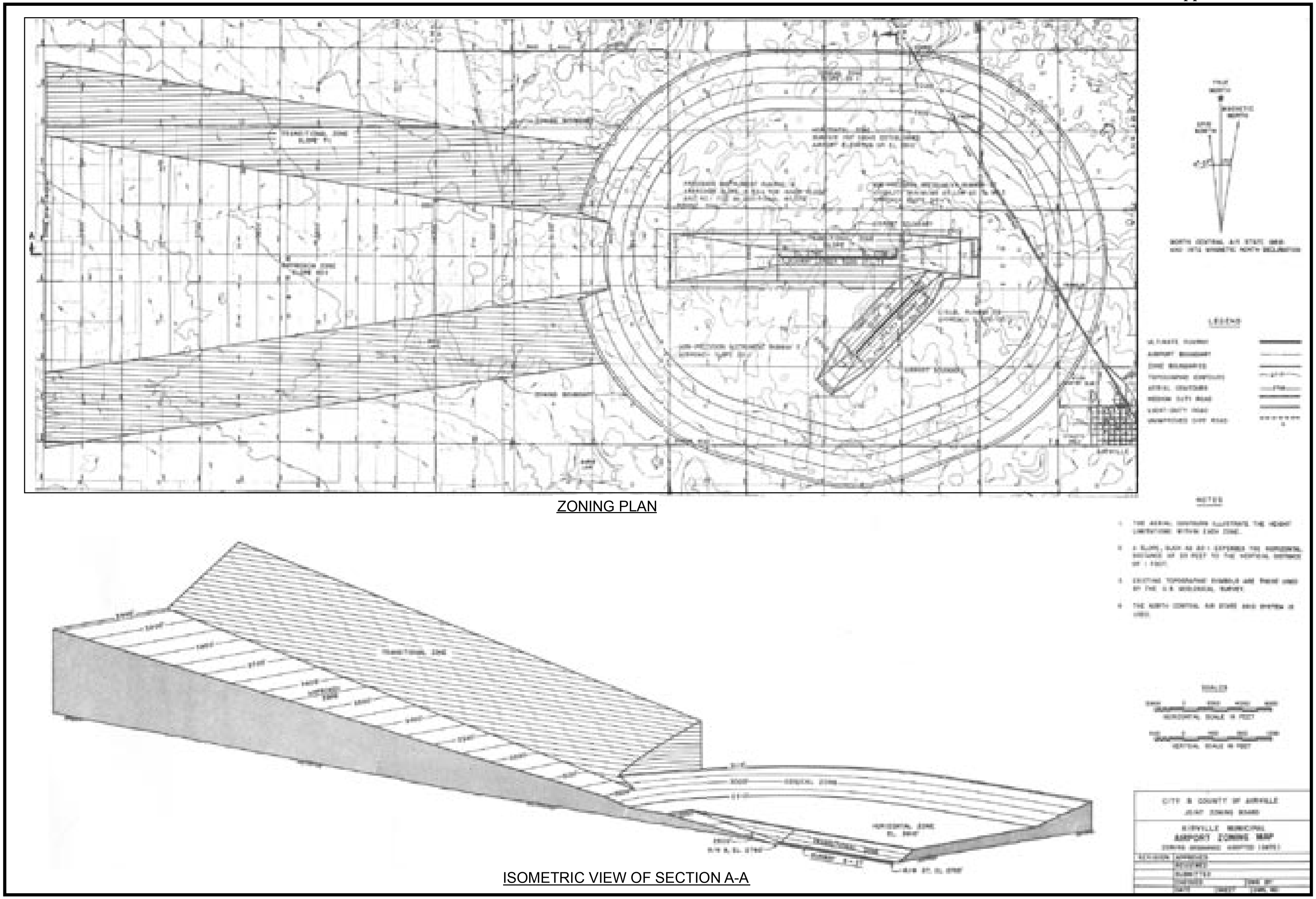

Figure 4—Model-zoning ordinance to limit height of objects around airports.

National Oceanic and Atmospheric Administration publication, Airport/Facility Directory. Maximum takeoff weight, wingspan, landing-gear configuration, approach category, and other data on most fixed-wing aircraft can be found in the FAA Advisory Circulars.

Runway requirements and/or load limits for specific aircraft at various elevations and temperatures should be obtained from the operation manual for each specific aircraft (contact your agency aviation specialist). Some useful information and the way this information is used can be found in FAA Advisor Circular 150/5340-1H (21).

A taxiway is a defined path established for the movement of aircraft from one part of the airfield to another. The taxiway must be capable of supporting the maximum takeoff weight of the heaviest aircraft expected. It is usually built to hold the same aircraft weight as the runway it serves, but not always. The taxiways must be wide enough to accommodate the wheelbase of the aircraft used and to prevent engine ingestion of, or propeller strike with, small stones or other foreign object damage/debris (FOD) along the taxiway.

FAA standards specify a taxiway width of 75 feet for Airplane Design Group IV (6) which includes the heavy airtankers currently under contract. The FAA specification for the taxiway obstacle free area width is 0.7 times the airplane wingspan plus 10 feet from the taxiway center line to a fixed or movable object (taxiway center line to aircraft parking limit line).

Rotor-wing operations. Rotor-wing aircraft, operating from a heliport, use a takeoff and landing area (cleared area) containing a final approach and takeoff area (FATO). The same area is also used for the takeoff maneuver. The FATO surface shall be capable of producing ground effect.

When more than one FATO is provided and simultaneous same direction (side by side) diverging operations are to be conducted, a center-to-center separation distance of at least 200 feet shall be provided (11).

When helicopters regularly utilize an airport where the takeoff and landing area is the runway, it is desirable to provide taxi routes that lead directly from that section of runway being used as the FATO to the helicopter parking area in order to reduce: potential air traffic congestion resulting from the slower taxi of helicopters, and the amount of trash and dust blown into other airport facilities by helicopter rotor wash.

The width of the cleared right-of-way (taxi route) provided for taxiing helicopters between a takeoff and landing area and a parking area shall be:

1. At least twice the rotor diameter of the largest helicopter which is expected to hover taxi; or,

2. At least 1½-rotor diameters plus 14 feet, of the largest helicopter which is expected to ground taxi

When a hard surface taxiway is provided for helicopters, it shall be centered within a taxi route and shall be at least twice the width of the undercarriage of the design helicopter (10).

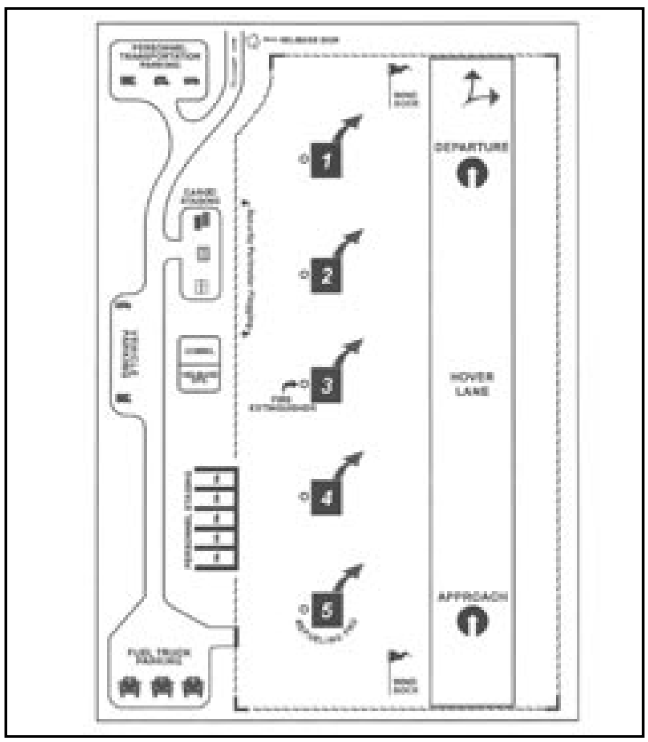

Figure 5—Helibase layout.

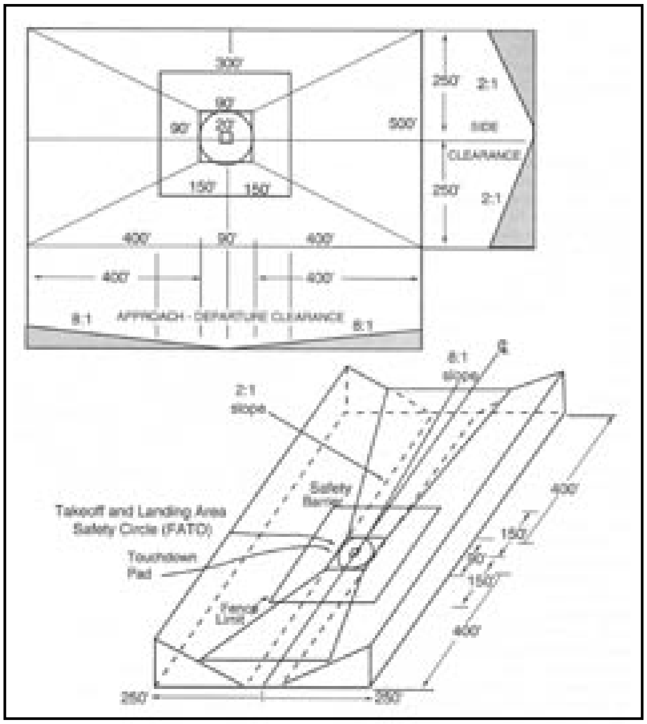

Figure 6—Helicopter obstruction clearances.

Ramp space—An apron or "ramp" is a defined area on a land airport, intended to accommodate aircraft for purposes of loading or unloading passengers or cargo, refueling, parking, or maintenance. The portion of the aircraft apron or ramp area used for access between taxiways and aircraft-parking positions (pads) is called a taxilane. Taxiways usually fall under the supervision of the Air Traffic Controller and construction and maintenance are normally functions of the airport authority. Taxilanes and ramps are normally under the jurisdiction of the agency responsible for airtanker operations, construction, and maintenance. For Airplane Design Group IV (large airtankers) the minimum taxilane width is 50 feet with 12.5-foot shoulders on each side.

The FAA specification for the taxilane obstacle free area (OFA) width is 0.6 times the airplane wingspan plus 10 feet from the taxilane center line to a fixed or movable object (taxilane center line to aircraft parking limit line).

Determine that sufficient ramp space will be available for the taxiing and parking of all aircraft anticipated to use the base.

Aircraft services—Plan for emergency services such as fire protection, crash and rescue, and paramedic. Where these services are not available from the local airport, city, or county, consider the cost of providing these services when comparing alternative locations.

Figure 7—Aircraft crash rescue vehicle.

Planners should analyze availability of the fuel services' supply system, storage, type, size and number of fueling trucks and the response time availability. Determine the policies on contractor-provided fuel. Access to fueling facilities or service by the fixed base operator (FBO) should be considered. Determine the city, county, and local airport authority policies and regulations that might influence fueling requirements.

Planners should determine offduty parking needs. Determine the availability, security, and cost for offduty parking at other locations on the airport. It is generally more cost effective to ensure that parking is available at other locations on the airport rather than providing additional aircraft parking facilities at the base. If an agreement for offbase parking is needed, it should be obtained during the planning process.

Retardant mixing and storage—In the analysis phase, space must be available for the storage, mixing, and handling facilities. Consider the number and type of aircraft to be serviced (based on type(s) best suited to service a given area and allowed at the site), as well as the maximum gallons per hour and daily requirements for retardant delivery to the aircraft. The proximity of the suppliers, restrictions on mixing some retardants onsite, and vendor ability to resupply retardant can affect dry or wet storage requirements.

Because of the very low mix ratios, a small amount of foam reacts with a large amount of water. The possible impact of small volume spills on the environment must be considered. The ability to adequately contain spills and washdown water to meet environmental laws and regulations must be considered.

Utilities—Consider the availability, size, capacity, and reliability of existing utilities.

The access to an adequate supply of electrical power and water is critical to the operation of a retardant base and is essential when determining the suitability of a site for retardant operations.

The water source, its supply rate and pressure, its purity, and its past history of availability should be defined and considered in relation to peak demands. If the pressure is inadequate for washdown or supply, consider the use of booster pumps. Water storage facilities may be needed to meet anticipated demand. The local fire marshal should be contacted for requirements regarding fire protection.

Determine the availability and type of electrical service available. Typically a 480-volt 3-phase service is desirable for the retardant loading pumps. Contact local service providers regarding location and availability of an adequate source of electricity. If a generator will be required, one of sufficient size should be planned into the project.

Stormwater disposal is another important consideration at each site. Consider each site's stormwater drain location, containment, and filtration in regards to local, State, and Federal stormwater laws, aquifer acts, and permit requirements.

Other utilities that must be considered are sanitary sewer, natural gas or propane, telephone, cable television, and Internet. While these utilities may not be required at each base initially, they may be needed in the future and should be considered when planning. If the required utilities are not available onsite, alternate provisions must be planned. Utility extensions and utility hookup fees can add substantially to the cost of base construction or improvements. For instance, onsite sewage disposal costs and space requirements must be planned where a sanitary sewer is not available. Service representatives from each of the utility providers can normally provide the information on availability and costs.

Vehicle access—Consider access for availability, size, capacity, and reliability. Vehicle access to the site must allow trucks to efficiently deliver retardant to the mix plant. Access for employee and contractor vehicles and fuel trucks should also be planned. Where access is not adequate, contact local transportation officials to determine the feasibility of providing access.

Plan to provide adequate onsite access roads, secured parking, and unsecured parking for retardant delivery vehicles, emergency vehicles, employee and contractor vehicles, and other vehicles that may be required.

Determine the amount of parking that will be needed for contractor and agency personnel who will be transported from the base via airplane.

Access control must be provided to restrict entry to areas as called for in the airport and base security plans. Electrically operated gates and security systems at entry points may be required.

Public viewing—In many cases the public will come to the base to view operations. Public viewing areas must be planned away from the restricted areas and should ensure that public vehicles do not cause traffic hazards along adjacent public roads. Visitor and vehicle counts may be needed during busy days or at nearby bases to determine the numbers of visitors and vehicles to provide for.

Figure 8—Public viewing area.

Other agencies and authorities—Review all applicable municipal, county, and State zoning laws and permit requirements for chemical handling, mixing and/or production plants, fuel transport, facilities, utilities, and access roads. The containment and disposal of spills and washdown water containing retardant, fuel, and oils must meet applicable environmental laws and regulations.

The following agencies and authorities should be contacted to determine their rules, regulations, restrictions, plans, and other factors that might affect base construction or operations:

Airport or port authority
City council
County commission
City and/or county planning department
City and/or county building department
City or State environmental quality agency
FAA
Cooperating fire agencies
Fire marshal
Other agencies and authorities that may have jurisdiction.

Location

For new permanent bases and temporary bases, determine all alternative locations that can accommodate the development needs and are within the required response time. Generally, the sites available for permanent fixed-wing retardant base operations are limited. Look at costs of development and operation at each location. For temporary bases consider access and ease of setup. Site selection must include selection of an airport in the appropriate location that is able to support the anticipated mission and meet the needs of the agency.

Airport selection—Priority must be given to: runway, taxiway and ramp bearing strengths, runway length, available ramp space, and the geographic location of the potential users of the facility. Selection of the location should also consider the coverage area in light of past fire history of the area, political considerations, interface responses, environmental concerns, noise abatement procedures, proximity of neighboring base locations and potential large scale interagency operations. Use a national fire management analysis system program or other modeling program to provide management with an approximate location and size for the new base.

The potential for conflicts with other existing and future user of the airport should be considered. For instance in an area where commercial development indicates that a rapid increase in corporate jet traffic and hangar construction may be anticipated, future air traffic conflicts and lease costs may hamper the agency's ability to operate.

The retardant base must be compatible with local airport authorities' master plan. A cooperative agreement, or lease, with periodic reviews will normally be required.

Site selection—Consider the possible impact of the location with respect to prevailing winds, taxi routes, ramp access, airport restrictions, and availability. Day/night approach facilities also may be a consideration.

In order to determine that adequate space is available, consider the number and type of aircraft to be serviced (based on type(s) best suited to service a given area and allowed at the site), as well as the maximum gallons per hour and daily requirements for retardant delivery to the aircraft. Sufficient space must be available for the storage, mixing, and handling facilities. The proximity of the suppliers, restrictions on mixing some retardants on site, and vendor-ability to resupply can affect dry or wet storage requirements.

Consider the availability of adequate water and electrical service; current utilities for access, availability, size, capacity, and reliability; current ground access for available capacity, restrictions, and reliability; and the airport security plan and the ability to secure the retardant base and aircraft.

Archeological and biological site surveys and analysis should be performed on all sites prior to final site selection and site development plan completion. Appropriate documentation must be prepared and approved in accordance with applicable environmental laws before project implementation.

Past use of each site should be investigated for possible HAZMAT contamination such as pesticide operations, other chemical spillage, or fuel and oil saturation. A soil sampling of each site must be performed prior to development planning.

Final site selection and acquisition

When alternate sites have been evaluated and the best site chosen, property rights for the site must be insured. If the agency does not have title to the land, a long-term lease must be secured prior to spending money for improvements. Typically a 40-year lease is the minimum requirement. Often, the long-term lease can be written so that the lease rate is adjusted annually or every 5 years.

For temporary bases, agencies often use a temporary written agreement. Temporary agreements need to be arranged in advance and activated as needed.

Written agreements may be required with, airport, county, city, and state authorities; the FAA; or a combination thereof. The agency official responsible for leasing or land uses should review the proposal and determine the need for General Services Administration involvement, leases, memorandums of understanding, or other written agreements. The agreements should cover flight patterns, noise abatement procedures, coded departures, priority handling, expedited services, fuel storage, fueling, landing and takeoff fees, methods of payments, security procedures and access, availability of additional staging and support areas, provisions for utilities, periodic facility inspections, crash and rescue procedures, abort areas, and settlement of claims for damage and injury. Agreements can sometimes include construction of facilities by the local or airport authority when they can recover their investment through landing fees.

SITE LAYOUT

Develop a concept plan for the layout of each base after the site has been located and decisions made on aviation uses to be accommodated and facilities to be constructed or improved. This is important for temporary and portable bases as well as permanent bases. The layout must take into consideration existing facilities condition and location in addition to future airport and transportation facility improvements. The concept plan will provide the guide to design and develop an efficient retardant base (see figure 9).

Spatial Relationships

A number of factors will determine the physical arrangement of each base. These factors include other users of the airport and facilities, the amount of space available, the types and mix of aircraft using the base, the type of retardant, and the typical and maximum expected load on the base (see figure 10).

The layout should provide for the safe and efficient movement of all types of aircraft onto the appropriate ramp area. The ramp area must be configured to provide adequate separation for different types of aircraft and functions. Separate light aircraft parking from airtanker loading areas and helicopter operations areas. Follow FAA recommendations for airport layout and design (6).

The pilots must have safe and efficient access to administrative areas and buildings from their aircraft without passing through other operational areas. Retardant loading pads and parking areas for loaded airtankers must have secondary containment for possible spills and they must be easily accessible from the retardant mix plant as well as from the base operations building. In order to maintain a safe work environment for those personnel loading aircraft, no other operations should take place in the retardant loading area. Other uses may be planned for the retardant loading pits when the pits are not being used for retardant operations, but those uses should not compromise the safety of the retardant-loading operations. Retardant storage must be readily available to the mix plant and delivery trucks. The area containing aircraft parking, retardant storage and mixing facilities, and certain other operational facilities must be secured in accordance with the airport and base security plans. Plan for some vehicle parking inside and outside of the restricted area. Administrative and public access can often be accommodated outside the restricted areas. Do not compromise safety or security to enhance access (see figure 11).

Locate working areas for personnel away or shielded from aircraft propeller blast (see figure 12).

Aircraft Traffic

Agreement should be reached with the airport for locating taxilanes(s) that will exit/enter the airport's taxiway to access the retardant base. If the taxiway or runway is not adequate for the anticipated aircraft, make the improvements to the runway or taxiway part of the airport master plan rather than the retardant base development plan since the airport will retain jurisdiction of the runway and taxiways.

Typically, design group IV large airtankers require 50-foot-wide taxilanes with 12.5-foot hardened shoulders on each side. The nosewheel line requires a radius of at least 85 feet, but 100 feet is preferable with a straight tangent section 10 feet prior to and 10 feet beyond the nosewheel parking point. Maintain clearances such as the object free area (OFA), building restriction line (BRL), and obstacle free zone (OFZ) in accordance with the latest FAA design recommendations (6).

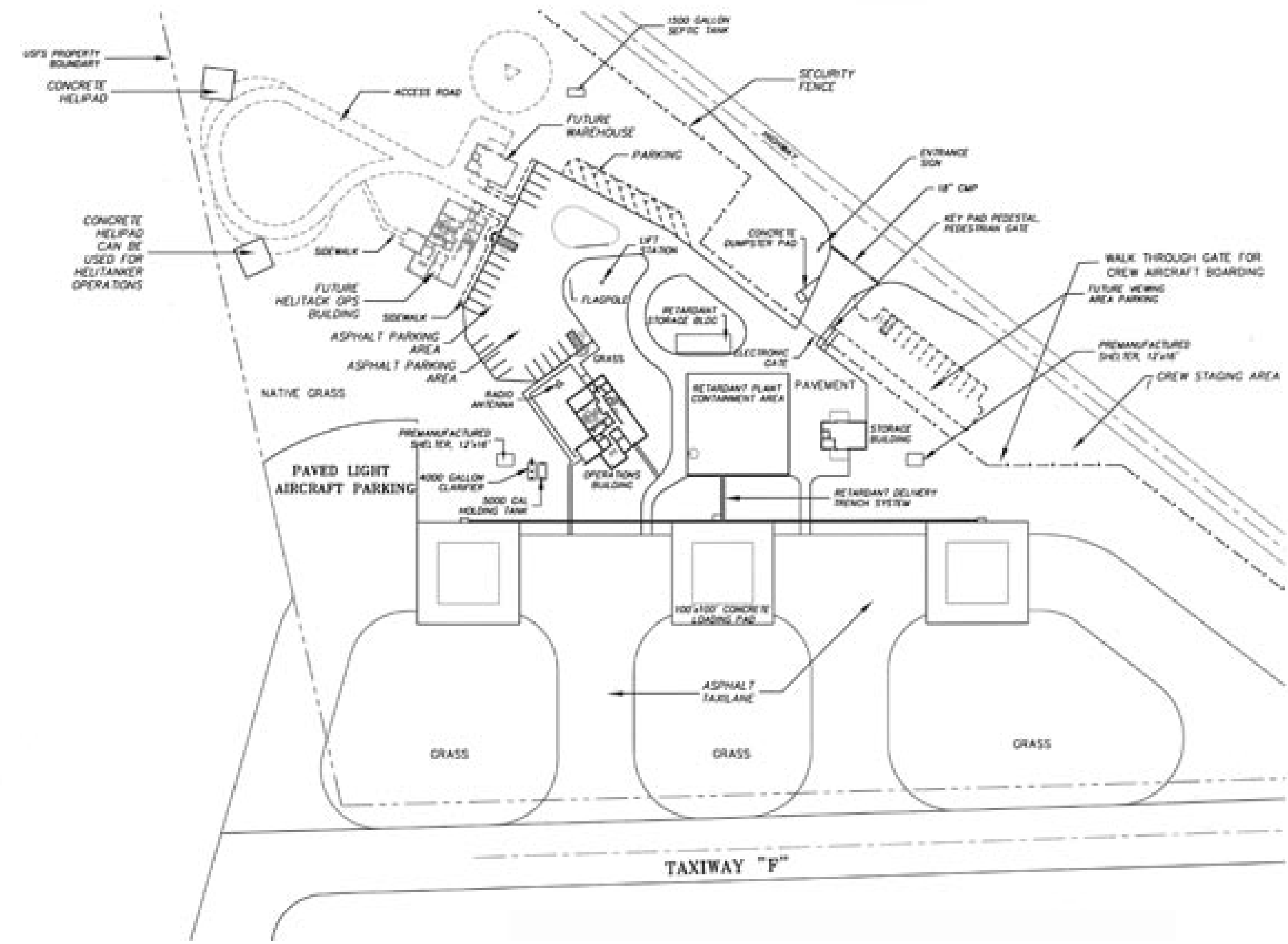

Figure 9—Retardant base layout with future helicopter operations (based on Chester, CA).

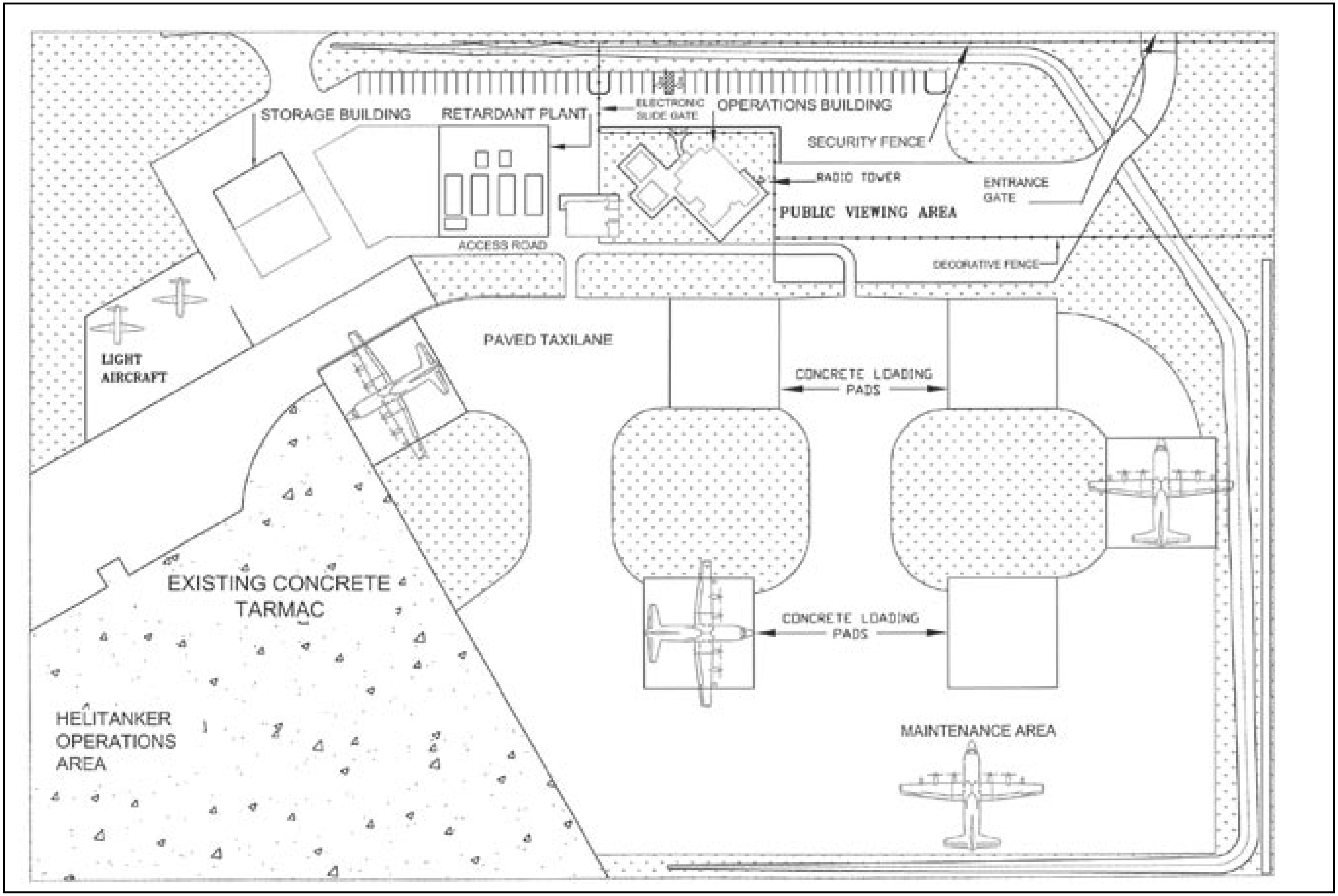

Figure 10—Retardant base layout with helitanker operations area (based on San Bernardino, CA).

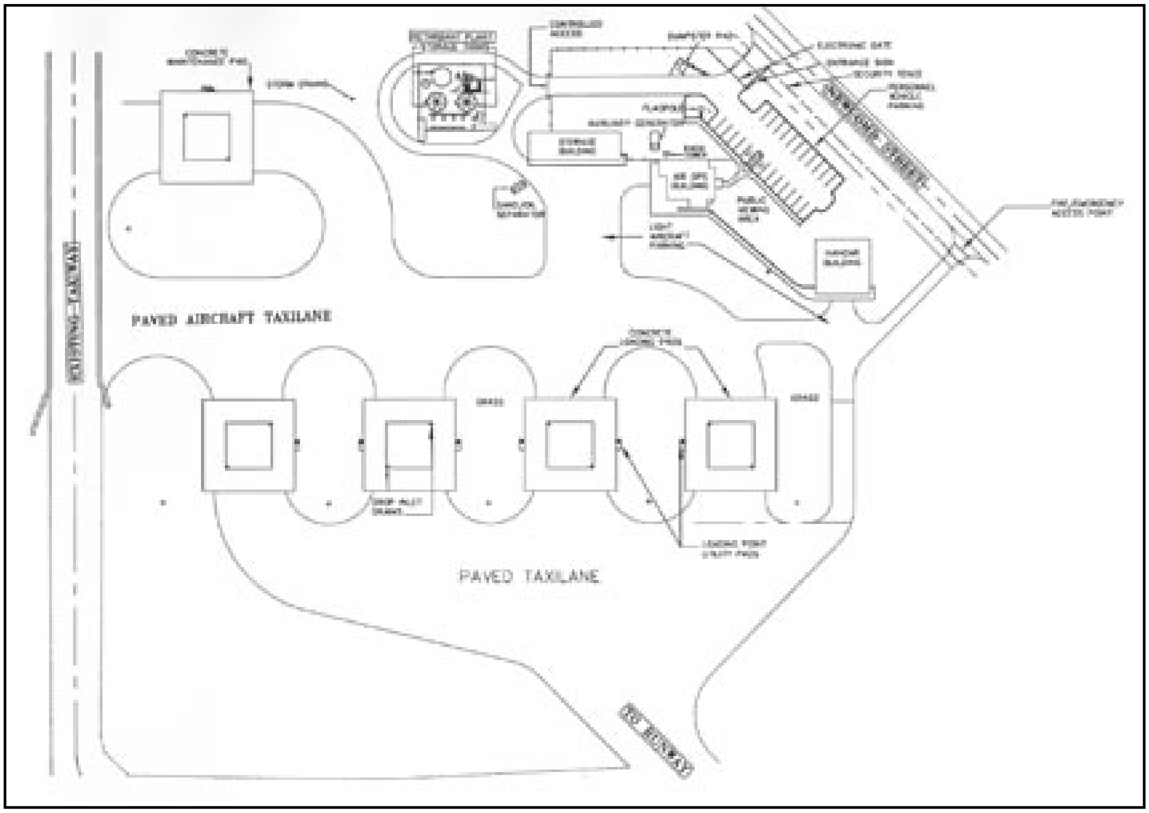

Figure 11—Retardant base layout with hangar (based on Porterville, CA).

Figure 12—Pull through retardant base layout (Durango, CO).

Access to the ramp area should be configured so that only aircraft that have official business at the retardant base will enter the taxilanes and/or ramp. Taxilanes should provide for unrestricted access to the ramp area and aircraft parking. Provide separate apron entrance and exit taxilanes to avoid traffic congestion and the need for a turnaround area. One way in and one way out are preferable. If two-way aircraft traffic must be accommodated, ensure that sufficient clearances are built in to avoid access being blocked by an inoperable aircraft. With larger heliport operations, the center or an end of the field provides the takeoff and landing area and the helicopters ground hover or taxi to and from parking areas (11).

Aircraft Loading and Parking

A pad or pit (also called gate position) is a specific parking place for an aircraft to load/unload, refuel, washdown, tiedown, do maintenance, and so forth. The types of activities conducted on the pad dictate the size, shape, construction, utilities, location on the ramp, and access restrictions. Each standard large airtanker-loading pad for design group IV aircraft should be 100 feet by 100 feet. Parking pads for loaded airtankers must provide spill and washdown containment. Full containment is not required for locations where aircraft will be parked without retardant on board. Orientation of pads should consider prevailing winds. If possible, turbine-engine aircraft should face into the prevailing wind when parked. Pad location should also consider prop wash effects on adjacent pads, workspaces, and facilities.

Aircraft ramp design will vary with the size and type of aircraft and intended aircraft usage. Configure parking for aircraft to allow each aircraft to enter and exit pads under its own power. When parked on the pad, the aircraft should be positioned so that engine-starting exhaust, jet blast, or breakaway prop- or rotor-wash will not hit other aircraft or occupied, unprotected work areas. Consider separate parking areas or blast fencing for light aircraft, fixed- or rotor-wing, that may be damaged by prop- or rotor-wash from heavy aircraft. Rotor-wing aircraft operations should be downwind from fixed-wing operations. Separate operational areas based on aircraft size should be provided.

The two most commonly used fixed-wing aircraft parking arrangements are tandem parking that is parallel to one edge of the ramp, and side-by-side or pull-through pads(see figures 13 and 14).

When tandem parking is used the starting exhaust and propwash can be abusive to the aircraft next in line. A nose-to-nose distance of 200 feet is recommended for design group IV airtankers when using a tandem parking arrangement. Using angle parking on the same pad directs prop wash away from other aircraft and reduces the distance required between the edge of the ramp and the aircraft parking limit line. Angle parking is accomplished by directing the aircraft to taxi in a circle until the aircraft is headed away from the ramp at about a 45-degree angle. Angle parking reduces the area that needs to be leased and paved because more aircraft fit in less space.

With side-by-side parking large fixed-wing aircraft enter, park, and exit the parking pad straight onto and from taxilanes on both sides of the pad. Side-by-side pads are used at some fixed-wing retardant bases because it provides eye contact between operations control and the pilot, reduces the number of required ramp personnel, provides better entry and exit visibility for the pilots, and reduces the amount of propwash on other aircraft. This results in safer and more efficient operations. Where side-by-side parking is utilized, loader shelters can be placed between the loading pads. Some retardant bases are often used for passenger or cargo operations. The retardant base layout should identify areas that will be used for cargo and passenger marshalling and manifesting. These areas should be large enough to accommodate large commercial buses and 18-wheel trucks without having them back up to turn around.

Parallel helicopter parking is used at smaller or ridgeline heliports where the helicopters land and park in a FATO. However, a design that requires a helicopter to park in a FATO or the takeoff and landing area makes that area unavailable for takeoff and landings by other helicopters. The helicopters may park on paved or unpaved aprons, individual helipads, and helidecks (elevated surfaces used for parking helicopters).

Vehicle Access and Parking

Provide adequate space for convenient vehicle and transport truck access and egress. There should be adequate room for vehicles to turnaround and maneuver without interfering with operations or each other. Arrange structures and facilities to allow emergency equipment to move freely and quickly to any incident or accident that

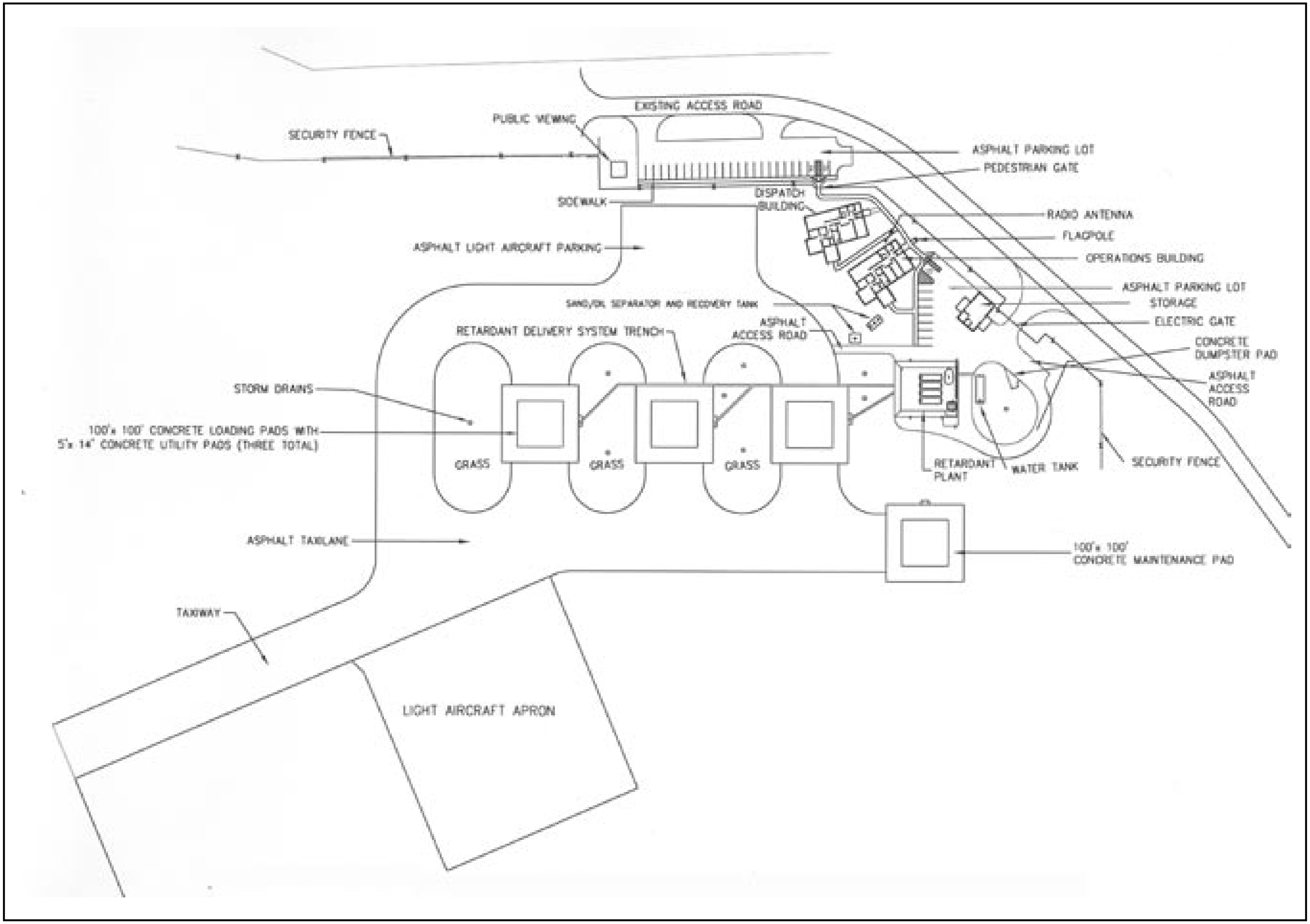

Figure 13—Retardant base layout with maintenance pad (based on Klamath Falls, OR).

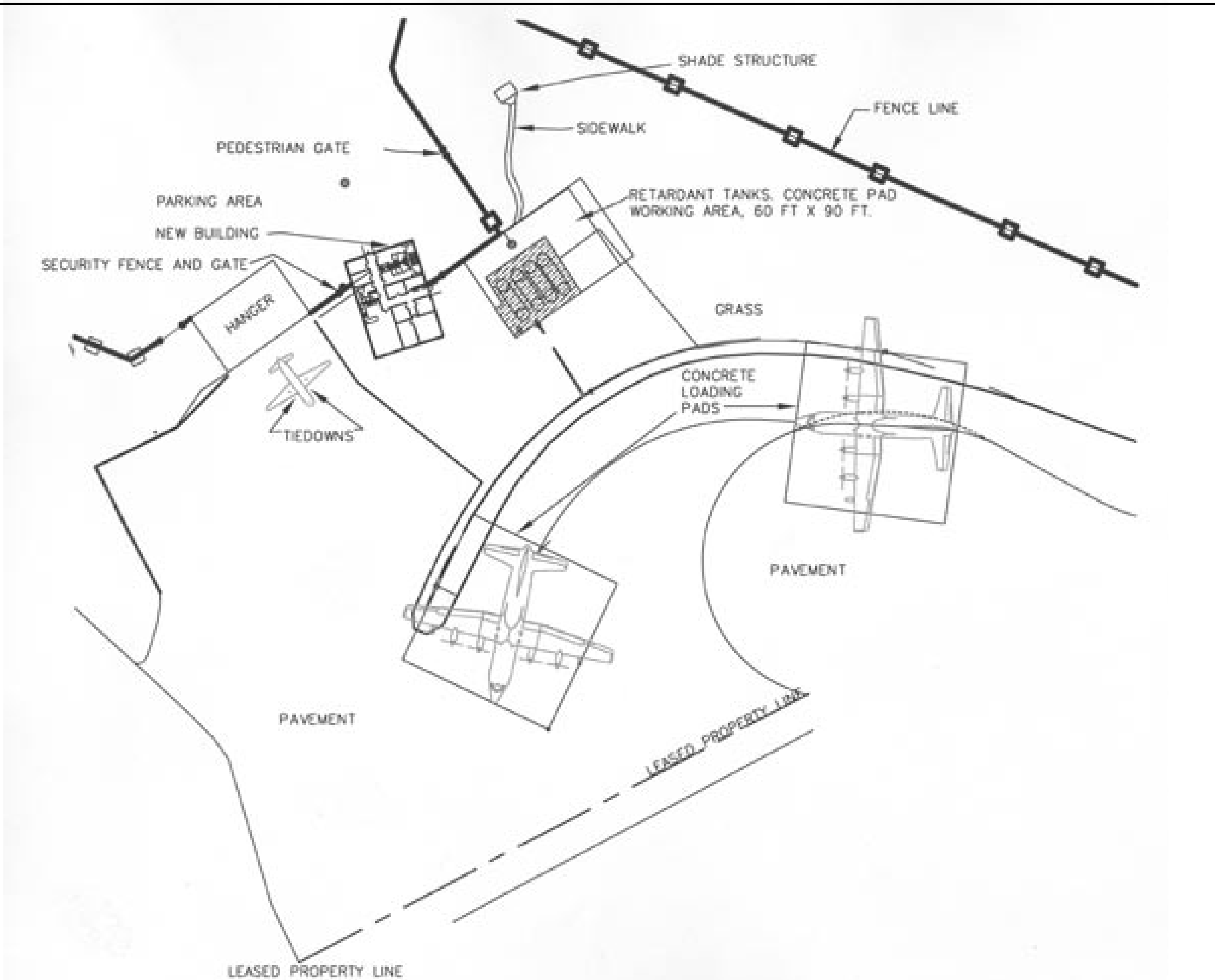

Figure 14— Retardant base layout using nose-to-tail loading pads (based on Medford, OR).

may occur on the base. Vehicle access to storage areas is a primary concern and should be located not to compromise the area used by aircraft.

Configure access roads and offload areas to provide maximum flexibility for delivery of all types of retardants currently available. Each base should have the equipment necessary to transfer material (both liquid and dry) from base storage to trucks for transfer to other locations. Consider alternate access methods.

Provide vehicle-parking areas that are large enough to handle the anticipated number of base employees and site visitors. Use secure fencing, gates, or other barriers to control access to the base operational areas and to provide secure parking for personnel that fly to other locations. Access of employee and visitor vehicles must be restricted and controlled by use of adequate security measures to protect the integrity of ramp and mixing site operations.

Parking is also required for ramp/plant operational vehicles such as forklifts, aircraft tugs, fuel trucks, emergency equipment, and maintenance vehicles. Space to park retardant transports waiting to unload should also be considered.

Public Visitor Facilities

Public access and parking must be strictly controlled and must be located outside of and secured from the restricted area. A separate area for the public to view retardant base activities is normally required to ensure a safe and pleasant experience for the public. The area must be large enough to provide vehicle parking off public roads and provide a comfortable viewing area.

Retardant Mixing Facilities

Configure the mixing plant so that any qualified dry product or wet product can be used with a minimum of modification. Locate the mixing plant, retardant storage tanks, retardant silos, and retardant pumps on one containment area with adequate access for forklifts. The area should be located to minimize the distance to all loading pits. Consideration should be given to minimizing the length of the retardant delivery trench and particularly the amount of trench requiring airplane-rated grating (see figures 15 and 16).

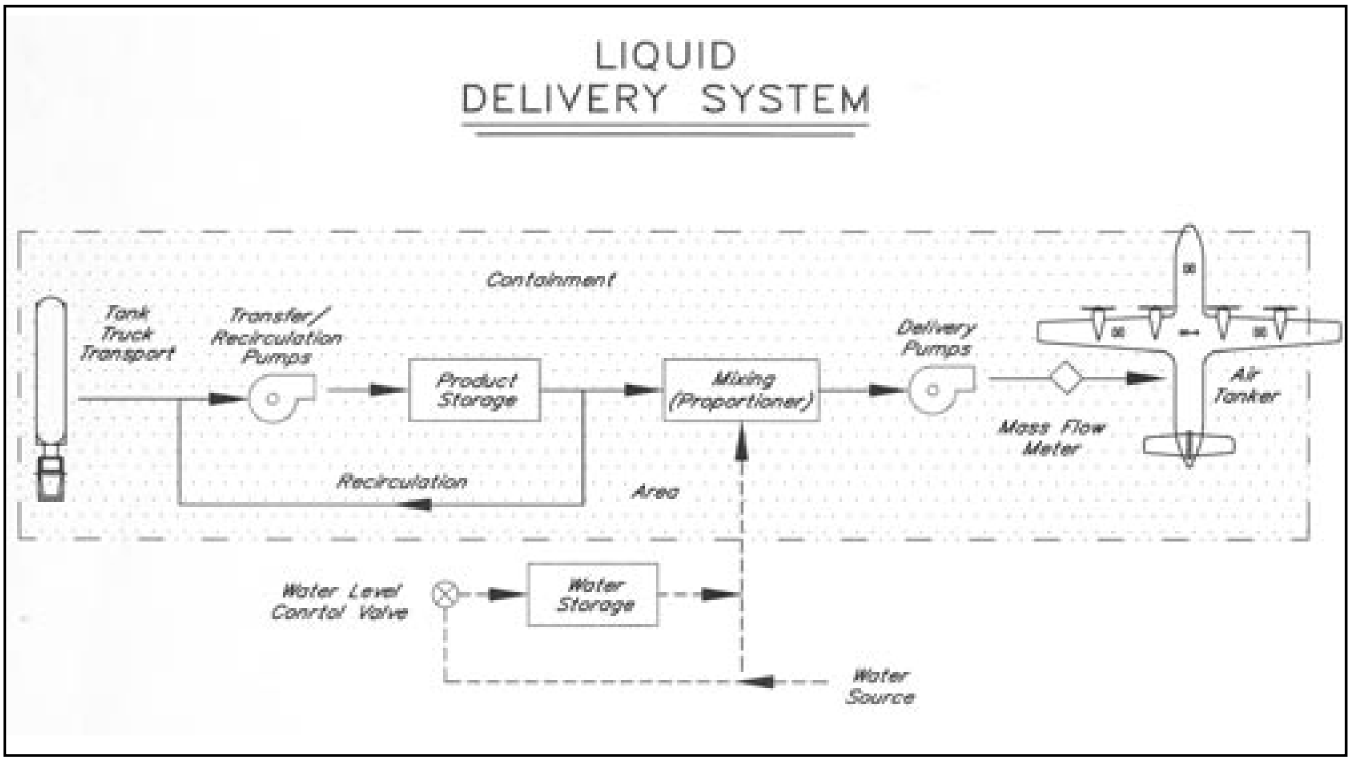

Figure 15—Liquid distribution system.

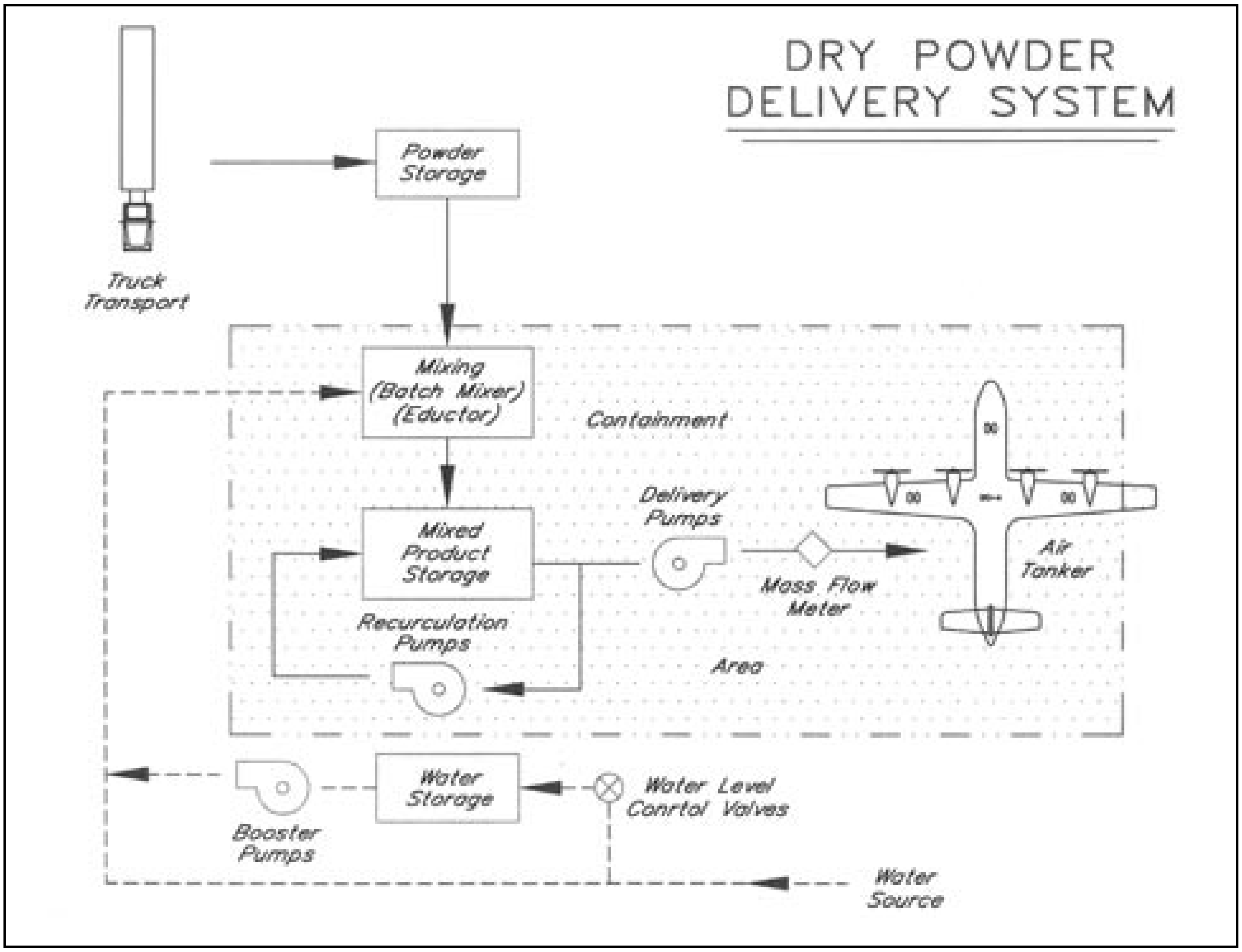

Figure 16—Dry powder delievery system.

The containment basin (secondary containment) for the retardant mix plant will vary in size depending upon the volume of the largest retardant tanks to be contained and the space needed for mixers. Secondary containment should be large enough to contain 125 percent of the volume of the largest tank. Ramps or gently sloping sides will provide forklift access and are often used to gain access to the tanks and pumps. Space should be available within the containment area for mixers even at bases that currently use liquid or fluid products. Retardant contracts are on a 3-year cycle so the product may change when a new contract is awarded. When the base uses a liquid or fluid product, the area set aside for mixers provides a flat hard surface for a variety of work activities. USDA Forest Service standard containment areas are 72 feet square for 10,000-gallon tanks or 100 feet square for 20,000-gallon tanks.

Retardant Storage

Bases should be designed to use either dry or liquid products. While the facilities constructed must accommodate the product currently being used (or planned), space must be planned for product changes. Liquid retardant products will be stored in tanks. Dry retardant products will be stored in silos within the containment area, airslide trailers, semibulk containers on a flat hardened surface, or storage buildings. Use a covered or enclosed building for overwinter storage of bulk containers. Fire suppressants and foams might be stored in buckets, on pallets, or in drums in a covered or enclosed structure. Since semibulk containers, pallets, and drums must be moved with a forklift, adequate pull-in/backup space is required. The storage area for product must be close to the actual mixing point to minimize haultime. The storage area should provide adequate space for the projected volume of product to be kept onhand (see figure 17).

Figure 17—Dry powder retardant storage silo (Porterville, CA).

Buildings

Thoughtful planning and analysis are essential to effectively define the size, type, number, and variety of structures and facilities that may be required at a permanent, temporary, or mobile airtanker base.

Typically, an operations building that meets the space requirements given in Section V. (D). will be required for permanent bases. Locate the building so there is good visibility of the retardant loading operation. It is also desirable to provide good visibility of the retardant mixing operation. It is helpful if the timekeeper sitting in the operations room can see both ends of the runway in order to record the actual time of takeoff or landing. Additional considerations are the visibility of vehicle and pedestrian access points and parking lots. Closed circuit cameras can be used if the location does not provide ideal visibility of all areas.

Locate a storage building that is readily accessible from the chemical handling facilities. The building should provide space for parts storage, hose and fitting repair, battery charging, and a range of testing and repair activities. Adequate space and facilities must be provided for storage of lot acceptance and quality assurance (LA/QA) equipment, test performance, and equipment cleanup. The building should be large enough for forklifts, hoses, pumps, eyewash fixtures, and other equipment that is stored over the winter. Typical storage building space requirements are given in Section V. (N).

A variety of other buildings such as retardant storage buildings, shade structures, and loader shelters may be needed.

Spill Containment and Drainage

Spill containment and drainage should be considered during the site planning and layout process. The layout of secondary containment structures for the loading pads and retardant mix plant must be connected to the spill containment tanks or lagoons, the washdown water disposal system (sand/oil separator), and the stormwater disposal system.

Fencing

Fencing for security and functional separation is an important consideration in base layout. The layout should maximize functional separation while minimizing the amount of fencing required.

Security fencing will be required to separate the restricted operational areas from the public and visitor areas in accordance with the airport and base security plans. Often this fencing can be configured to allow partial public access to the site so that parking, trash pickup, public viewing, and base visitor entry can be accommodated without impacting base personnel.

Operational fencing is sometimes required to separate areas within the secured or restricted area. Fencing should be the last resort, but can be used to keep visitors, passengers, or other personnel from wandering into operational areas that might be hazardous.

Site Amenities

Several site amenities may be needed on the site concept plan to ensure that FAA standards are met and adequate space is allowed.

Radio tower

A radio tower is commonly installed at all permanent retardant bases. It must be large enough to carry the necessary antennas, microwave dishes, and so forth. It must be located and sized to stay below the height restrictions for air operations. FAA normally must review the location and height prior to installation.

Site lighting
Site lighting is needed for security and for work areas used after dark. While final location and configuration of the lighting comes during the electrical design phase, a general location should be included on the concept plan. Typically, some of the site lights will be on poles that must be located and sized to stay below the height restrictions. Lighting must be configured to avoid impacts on aircraft landing at the airport. FAA will normally review lighting location and configuration prior to approving installation.

Flagpole
A 20- to 30-foot-high flagpole is installed at most bases. The location and height should be planned to stay below FAA height restriction.

Figure 18—Retardant base operations building (San Bernardino, CA).

Signing
An entrance sign is typically installed at the entrance to the base from the airfield side and the land side. Locate a standard agency site entrance sign at the vehicle entrance. It should be visible by all vehicles approaching. An FAA-compliant sign is typically installed at the entrance to the agency taxilane. Consider visibility, regulatory, and safety factors in the location of these signs.

Shade structures/Shelters
Shade structures or shelters are often provided near the operations building, mix plant, or loading pads. Locate these structures to provide a convenient place for pilots, loaders, mix-plant personnel, or others to relax out of the sun between work activities. Size and location should be appropriate for the function being served. Location and height must stay within the FAA parameters set for buildings.

Landscaping
While the concept plan does not need final landscaping details, it should include primary landscape features. Show bushes or shrubs used for windbreaks or for separation of functional areas and indicate grassy areas.

Satellite dish
At some locations a satellite dish is required for adequate television reception. If the dish cannot be mounted on a building or radio tower, the concept plan should show the dish's location.

Dumpster
A dumpster is typically used for trash disposal at a permanent base. Plan the location of the dumpster to provide easy access for operations personnel and easy access for dumping. Often the dumpster can be located on a hard pad adjacent to the operations building but outside the security fence. Where this is possible, trash pickup does not impact base personnel. If security or vandalism is an issue, locate the dumpster pad inside the fenced area but accessible to the trash pickup vehicle.

PROSPECTUS AND DESIGN NARRATIVE
The prospectus and/or design narrative should document the planning decisions in sufficient detail that the designers can develop detailed construction plans and specifications.

Purpose and Content
The prospectus includes enough information about facilities, site amenities, and utilities to guide the designers and the official that negotiates the land acquisition for the base. The prospectus will include all information on current use, future use, site development implications, and government agencies that pertain to the selected site. The prospectus will document the results of the analysis that determines the type and number of aircraft and vehicles that will use the site; the types of uses that will be accommodated; the number and criteria for the buildings required; specific design requirements including telecommunications requirements, local building codes, wind and snow loading, and

seismic zone; retardant operation criteria such as force account or contract and type and volume of retardant to be designed for; utility providers and contacts; and site amenities. Include project scheduling, funding, and phasing in the prospectus. A prospectus template is available from the USDA Forest Service, Missoula Technology and Development Center, Facilities Program.

Design Guidance

Specific design guidance is included in the prospectus. Specific guidance is needed to ensure that metals used in chemical handling facilities are compatible with all retardants. Typically, galvanized, aluminum, or brass components are not specified where they would come into contact with retardants. Carbon-steel piping and steel tanks typically are satisfactory. All components and any corrosion inhibitors or coatings should be analyzed for cost effectiveness versus frequent component replacement.

Safety

Handling, mixing, and loading of fire retardant chemicals, aviation fueling, and maintenance have associated hazards that should be recognized. These hazards are applicable to the operation of any base. Safe work practices must be followed to ensure that the appropriate Occupational Safety and Health Administration (OSHA) regulations and requirements from agency manuals and base operating and safety plans are met.

Physical plant safety provisions, permanent or temporary, are important for personnel to operate in a safe environment. All facilities, fixtures, and equipment must comply with OSHA regulations (22), applicable codes, and agency regulations. Color-coding of fixed facilities is needed as an aid in the identification of hazardous areas and equipment.

OSHA requires that warning color-coding and signs be in accordance with Color Definitions, ANSI, Z 53.1, Section 3 (15). Pipelines should be color-coded in accordance with ANSI, A 13.1 (16).

Fire extinguishers are required at all operational and temporary bases (1).

Figure 19—Fire extinguisher and portable eyewash (San Bernardino, CA).

Mixing facilities

Permanent bases will be designed with enough flexibility, capacity, and space to allow use of all retardant products currently available. However, the prospectus must indicate which type retardant and mixing system will be used initially. The retardant type, required mixing method and equipment, and volume of storage must be determined and documented.

Prior to the design phase and during the planning phase, contact the retardant manufacturers to ensure that the proper consideration has been given to “new” developments. Supplier-provided information is essential for complete system planning and design.

Part of the overall analysis will be the determination of the most cost-effective method of mixing and loading. Will the base be a “force account” operation, with all equipment purchased, owned, and operated by the agency?

Or, will the base be a “contract” operation, with a contractor providing a combination of personnel, mixing, storage and delivery system equipment?

Plan retardant output to supply the seasonal, daily, and 2-hour retardant demand. Determine the maximum demand by projected or historical peak condition. Season of operation, initial construction costs, and personnel availability should be used when considering highly automated versus labor-intensive facilities.

The chemical mixing facility may also require facilities for handling foam or other fire suppressants. Chemical storage and mixing requirements are usually different for foam or other fire suppressants than for long-term retardants. The chemical storage and handling systems for foam and other fire suppressants are normally smaller and require separate water pumps, piping systems, valves, and loading hoses.
Because LA/QA samples must be sent to the Missoula Technology and Development Center for analysis, shipping containers and labels are required. Document the number of containers required and where they will be stored.

Chemical off load and storage facilities
Determine the requirements for retardant delivery, offloading, and storage for the retardant to be used at the base. Requirements for all types of retardant should be considered and provided for where economically feasible. For instance, where a wet concentrate is used, there is not a need for a flat-surfaced area for bulk container storage or mixers. However, additional flat-surfaced area can be constructed to provide additional workspace. If this flat surfaced area is located and constructed correctly and the product changes in the future, it can be used for mixers or bulk-product storage.

Retardant concentrate and dry powder are transported to the retardant base by tractor/trailer units. Depending on the product, the trailer may be a flatbed, tanker, or airslide unit.

While each of these units will have slightly different requirements for offloading and testing, there are also common requirements. Important information on the receipt and acceptance of retardant is contained in the Lot Acceptance, Quality Assurance (LA/QA) and Field Quality Control for Fire Retardant Chemicals (2).

Figure 20—Airslide trailer.

Figure 21—Semitruck delivering bulk bags.

Figure 22—Semitruck delivering bulk bins.

Figure 23—Wet concentrate tanker.

- Access road for retardant delivery should be paved and meet the geometric requirements for safe operation of a fully loaded tractor trailer unit of the maximum size allowed on the State highway system.

- Offload areas for trucks should be the pull-through type and should not require the truck be backed up.

- Access roads and offload areas should be configured to provide maximum flexibility to allow delivery of all types of retardants currently available.

- Each base should have the equipment necessary to transfer material (both liquid and dry) from base storage to trucks for transfer to other locations.

Specific storage requirements will be determined after a review of the history of fire and retardant use in the area. Maximum seasonal, daily, and 2-hour retardant demand rates must be established. These can be converted to raw chemical equivalents with the aid of standard mix factors determined by Wildland Fire Chemical Systems (WFCS) and included in the National Long-Term Fire Retardant Requirement Contract (3).

The time required from dispatch of a chemical from the manufacturer's supply point to receipt at the base facility, and the daily peak demand for mixed retardant to the aircraft, will influence the size of the storage system. For example, storage requirements can be determined by multiplying the daily peak retardant demand (gallons or pounds per day) by the delivery time in days. Multiplying the result by 1.5 or 2 can include a factor of safety. Conversion of the retardant demand rates to raw chemical equivalents will help identify the quantity of chemical that must be in storage, in transit, and on order if the demand is to be met. Consider tradeoffs between bulk containers, additional crew, and mixers. Additional storage may be desirable, if the transfer of product from truck to storage onsite takes a considerable amount of time, particularly if the transfer period is combined with long delivery times. Consider that during peak use, offloading of dry powder containers may be slowed if the only forklift available is needed for the mixing operation.

Loading airtankers elsewhere is an economic tradeoff that may be considered, if a shortfall is expected to occur only once or twice a season. It may not be economically feasible to increase the storage area when such an increase would only be used for a small percentage of time.
If foam or fire suppressants will be needed at the base, storage should be planned to accommodate 55-gallon drums or 5-gallon pails. These products are often delivered on pallets and can be offloaded with a forklift.

Aircraft access
One of the most important considerations in design is the type of aircraft that will use the base. A complete listing of types of aircraft and anticipated number of landings per year is required for taxiway and ramp pavement design. Any special requirements or limits on access to the airports taxiways and runways should be documented in the prospectus.

Typically, taxilanes used by design class IV large airtankers are 50 feet wide with 12.5-foot hardened shoulders on each side. The nosewheel line requires a radius of at least 85 feet, but 100 feet is preferable. Maintain OFA, BRL, and OFZ clearances in accordance with the latest FAA design guidelines (6). Ensure that any exceptions to the standard requirements are documented.

Airtanker loading
The area where airtankers are parked and loaded with retardant is referred to as a pad or a pit. The number and configuration should be documented on the site concept plan. The prospectus should indicate the numbers and types of aircraft to be loaded and the desired surface type. If the pads are to be used for fueling operations or for maintenance as well as loading, this should be documented so the designer can provide for those needs.

Any special equipment needed at the loading pad (such as start carts, provisions for loading water, or telecommunications equipment) should be indicated.

Figure 24—Airtanker loading pad (San Bernardino, CA).

Aircraft parking
Include the amount and type of aircraft parking in the prospectus. Consider the need for ramp area or pads for fueling, airtanker maintenance, and light aircraft (leadplane and other) parking. Describe areas required for cargo or passenger loading and unloading. If airtankers are to be parked while loaded the designers will need to know type and number of aircraft. Determine and document fueling locations. Document the need for special equipment or services (such as start carts, 220-volt electrical outlet, communications equipment, or special lighting). Identify the number and type of aircraft requiring tiedowns.

Buildings

It is important to define the building requirements in enough detail that the designer can provide facilities that are efficient and cost effective. In many cases, the use of national standard buildings will meet the needs while reducing design costs. The floor plans and design packages for standard operations buildings, storage buildings, retardant storage sheds, and shade structures can be obtained from the USDA Forest Service, Missoula Technology and Development Center, Facilities Program. Where the use of standard buildings is not appropriate, the prospectus must clearly define how many people will be using the buildings, and for what purposes. Season of use is also important for HVAC design.

Operations—Standard building designs are available for several base sizes. If none of the buildings are appropriate, the designer will need to know the approximate area needed for different functions including pilot briefing, timekeeping, manager's office, assistant manager's office, storage, utility and laundry, pilot quietrooms, kitchen and eating area, readyroom, and contractor's office space. Information should be provided on the types and numbers of employees, contractors, pilots, and other personnel that will use the building. Any special equipment such as an icemaker, refrigerator, washer/dryer, microwave, and cooktop should be specified. The size, orientation, and desired location of any aviation maps should be noted.

General storage—Where the use of standard buildings is not appropriate, the prospectus should define what is to be stored, any special storage or work area requirements that should be included, and any requirements for office space or restrooms. The number and activity of people using the building should be noted. Special equipment such as forklifts, pumps, aircraft tugs, and so forth should be included. Requirements for heating or cooling should be given. Consider overwinter storage of base equipment. If there is to be plumbing in the building, the prospectus should call for heat- or freeze-proofing provisions for the building. Consider lighting and telecommunications needs in the building.

Retardant storage—Standard designs are available for pole-style buildings and for enclosed storage. Where these designs are not appropriate, specify the type and amount of storage needed. If shelving or racks are needed to store foams or other fire suppressants, document the storage needed. Consider lighting and telecommunications needs in the building.

Figure 25—Retardant storage structure.

Shade structure/shelter—Where the use of standard buildings is not appropriate, the prospectus must clearly define how many people will be using the structure and any specific requirements.

Pilot readyroom—Periodically, it is necessary to build a separate building to serve as a pilot readyroom. Where this is necessary, specify the number of personnel to be accommodated and the type of facilities needed. Typically a stand-alone readyroom has a kitchen/eating area, a lounge area, one or two quietrooms, minimal office provisions, and restrooms. Sometimes a small room is provided for exercise equipment. Consider large and normal incident operations when determining how many people will use the facility. A shaded outdoor gathering area can be specified to relieve congestion in the building during large-scale operations and to provide an alternative waiting area for the on-duty pilots.

Hangar—Typically the agency engineer will specify that a hangar be designed and constructed by a reputable firm with experience in airport-hangar construction. It is important that the engineer have the information on aircraft type and numbers, storage requirements, and ancillary activities (maintenance, parts storage, office) that will need to be located in the hangar. Requirements for heating, air conditioning, special lighting, or other special needs should be listed.

Figure 26—Hangar (Porterville, CA).

Utilities

The prospectus should include all the information that is available to the planner about the site utilities.

Water—Since an adequate supply of water is essential to the operation of any retardant base it is very important that proper planning be done and documented. The water source must be able to provide an adequate supply of potable-quality water for mixing operations as well as for buildings. **Never use washdown or wastewater for mixing retardant since production of a "certified" product requires use of potable water.** The specific volume requirements for retardant operations will be determined after a review of the history of fire and retardant use in the area. Maximum seasonal, daily, and 2-hour retardant demand rates must be established. This is a critical step in determination of the water storage requirements. Document the location of the water source and any constraints or concerns. List the supplier and, if possible, identify a contact person.

Electrical—The location of electrical service and constraints determined during planning should be documented. List the supplier and, if possible, identify a contact person.

Sometimes it is more economical to plan to use gasoline pumps and portable base operations during a power outage than it is to provide a generator. However, if backup electrical service is required, identify the critical functions to be served.

Gas—The type of gas (natural or propane) to be used should be determined. Document any special concerns or constraints. List the supplier and, if possible, identify a contact person.

Sewer—It is important to give the designer any information that has been collected from the airport, city, or other governing authority on the location, capacity, requirements, and regulation of the existing sewer system. Document any special concerns or constraints. List the governing authority and, if possible, identify a contact person.

Storm drain—While the existing storm drains are normally shown on the site plan, it is important to give the designer any information that has been collected from the airport or other governing authority on location, capacity, requirements, and regulation of the existing storm drain system. Document any special concerns or constraints. List the governing authority and, if possible, identify a contact person.

Communications (radio/telephone/computer)

Agency telecommunication specialists should be involved in planning, designing, and constructing the retardant base. Define and document design and construction requirements in the prospectus. The agency telecommunication specialist and planning team should determine the type and location of equipment that will be required at the base. If the agency specialist will install all equipment and cabling, this information may be omitted from the prospectus. However, all equipment, cabling, and other features that will be furnished and/or installed by contract should be defined.

The communications tower and antennae are key elements. Document the size, location, and loading requirements. If a specific type of tower is required it should be documented.

Security

As part of the planning process, an assessment must be made of base security requirements (20). The base security plan will define many security features that must be included in base construction or improvement. Include the security assessment as an attachment to the prospectus. Have qualified local and agency law enforcement personnel participate in the assessment.

Vehicle access

Many different type trucks are used to deliver retardant. The prospectus should indicate what types of trucks are expected at the base. Consider past deliveries and the possibility of larger trucks as a result of base improvements. Consider the delivery of all types of retardant.

In addition to retardant-delivery trucks, list all other large vehicles that are anticipated on the site. Some examples are fuel, garbage, propane, parcel/freight, fire, and busses. If there are specific areas on the base that these vehicles need access to, then those areas should be defined in the prospectus.

Any special requirements of the transportation agency responsible for access routes should be documented. The location of connections to these routes should be shown on the concept plan. Any constraints associated with the connection should be given.

Surfacing type and dust control requirements should be identified in the prospectus.

Vehicle parking
It is important to determine the anticipated number of vehicles that will be parked at the base at any one time. It is also important to identify how much parking needs to be secured and how much can be open to the public. Requirements for parking should include the number of spaces for base personnel, visitors, and the public. Identify overflow or high-demand parking if there may be occasions when many additional vehicles will need to be parked. Specify any specific fencing or security requirements for the parking areas (such as key card entry control on gates).

The prospectus should also document the parking requirements for ramp/plant operational vehicles such as forklifts, aircraft tugs, fuel trucks, emergency equipment, and maintenance vehicles. Also consider space to park retardant transports waiting to unload.

Identify surfacing type and dust control requirements in the prospectus.

Lighting
Identify lighting levels and areas to be lighted in the prospectus. Much of this information may be defined in the base security plan. Identify areas that should be lighted for walking and working. Spell out any special needs for lighting.

Signing
The prospectus and concept plan should identify the type and wording of signing required. Define base identification signs for aircraft and for the vehicle approach. Identify signs required for separation of restricted areas and other security needs the base security plan or in the prospectus. Spell out any special needs for signing.

Figure 27—Restricted area signing (Redding, CA).

Figure 28—Site entrance sign (San Bernardino, CA).

Landscaping
Landscaping is an important feature that can help define and separate functional areas, abate dust, and provide an environment that helps with stress reduction for pilots and other workers. Identify specific features or areas to be designed in the prospectus.

BASE COMPONENT DESIGN CONSIDERATIONS

All facilities and features at the base should conform to the FAA guidelines for airport layout, design, and construction (6). Even though these guidelines are not mandatory for projects that are not constructed with Federal grant funds, they should be followed to the extent possible on all projects. Rigid and flexible pavement structural design should utilize the FAA design method. This will typically require that the concrete to be used for aircraft traffic be specified by tensile strength requirements.

Design and construction should conform to all applicable codes and standards. Give special attention to conformance with environmental laws and regulations including those pertaining to wastewater and spills.

Retardant used for fire suppression is not a hazardous material by definition. However, when retardant is contained in washdown water or spills, it becomes a waste that must be disposed of in accordance with appropriate regulations since it contains substances that are controlled by environmental law.

Final Site Layout Plan

The final site layout plan will be prepared to ensure that the site layout accommodates the required uses in a manner that conforms to the prospectus, FAA guidelines, applicable codes and standards, and good engineering practices. The concept plan should be utilized to the extent possible, but may be adjusted to ensure that adequate clearances, drainages, and space requirements can be met.

Access and Parking

Design vehicle access and parking to accommodate all trucks listed in the prospectus including retardant delivery trucks, fuel trucks, and semitrucks. Consider multiple accesses where possible. Pull through routes for delivery trucks and for light vehicles is preferable. Design access for retardant delivery and fuel trucks so that trucks do not have to back up. Follow the guidance in the prospectus for the number of secured and unsecured parking spaces. Access routes and parking should be paved and striped. Use agency or American Association of State Highway and Transportation Officials (AASHTO) guidelines for design.

Consider access and parking for public viewing. Public viewing must not block adjacent traffic ways or create safety hazards along public roads. The use should be accommodated or signed and enforced to ensure that no unsafe condition develops when the base is in operation.

Figure 29—Retardant base access road and parking lot (Moses Lake, WA).

Taxiways/Taxilanes/Ramp

It is important to distinguish between taxiways and taxilanes. Taxiway construction, improvement, and maintenance are the responsibility of the airport and under the jurisdiction of the FAA. The airport authority designs and constructs taxiways. If the agency becomes responsible for taxiway or runway construction or improvement it is critical that FAA standards be used including asphalt mix designs and FAA specifications. Have the design reviewed and approved by the airport authority and FAA prior to contracting the work.

However, if the taxiway and or ramp will be constructed with Federal agency funds other than FAA funds, the FAA guidelines are not mandatory and some flexibility may apply. Safety-related guidelines such as BRL, OFA, and OFZ must be observed. The FAA method of rigid or flexible pavement design should be used to determine the structural section that is required to support the type and numbers of aircraft anticipated.

The designer should base turning radii, nosewheel line radii, wingtip clearance, aircraft spacing, and so forth on the largest aircraft anticipated to use the base. It is often necessary to consider the wingspan of one aircraft and the length of a different aircraft to ensure that adequate clearance is maintained. For rotor-wing aircraft, determine clearances in accordance with the Interagency Helicopter Operations Guide (IHOG) (11).

Separate light aircraft, rotor-wing aircraft, and heavy airtanker parking for safety. Pullthrough parking is preferable to parking that requires a u-turn or a push back. Aircraft should have alternatives for ingress and egress so that operations can continue if an aircraft is disabled on the ramp.

Provide fixed-wing aircraft with paved taxilanes and ramp space. Taxilanes for rotor-wing may not be paved if adequate dust abatement can be provided through the use of grass or other surfaces.

Pave parking areas and install tiedowns for all light aircraft. Tiedowns may be required for larger aircraft if the base may be subjected to extremely high winds.

Loading Pad

Loading pads are often referred to as “pits.” The standard large airtanker loading pad is 100 feet by 100 feet. These pads are subject to spillage, leakage, and after-drop dripping. Retardants that contain ammonium sulfate will erode most concretes and guar gum will spall (flake, chip, or fragment) asphalt surfaces. Retardant loading pads should be constructed with type-15 (sulfate-erosion resistant) concrete with appropriate air entrainment to prevent damage from winter freezing. The structural design should conform to the FAA design method for rigid pavement. This will typically require that the concrete used by aircraft be specified by tensile strength requirements.

Figure 30—Loading pad wash down water collection trench with grating (San Bernardino, CA).

The grades and alignment for the taxilane approaching the pad and on the pad should be in accordance with FAA design guidelines (6).

The designer should ensure that large airtankers have a 10-foot tangent in the nosewheel travel path on both the approach and departure side of the nosewheel parking position. This allows the aircraft to be parked with the nosewheel straight.

Since airtanker washdown is usually accomplished while the aircraft is on standby on the loading pad, ensure that the concrete joints and any cracks on this pad are sealed. Sealing should prevent subsoil saturation to the extent that the concrete begins to shift and break up. The pads must be configured to contain all spills and washdown water. The surface of the pad is to be roughened in accordance with OSHA requirements. Typically a light-broom or a burlap-drag finish is adequate. These pads should be adequate for the occasional passenger or cargo loading/unloading function.

Design each pad or ramp to collect and direct the flow of all spillage and washdown residues into a holding area for disposal that meets the requirements of environmental regulations and laws.

Two common types of construction for pads are the pan-shaped pad and the sloped slab that drains to a side trench. Collection system design often dictates which shape is more efficient at a given base. The pan-shaped design utilizes slopes on all sides so that water and spills are directed to a grate or grates in the middle portion of the pad (not directly under the aircraft). The sloped slab utilizes a 1 percent side slope that drains to a trench on the downhill side of the pad (6). The trench on the side is often used for running retardant delivery pipes to the loading point as well as for secondary containment. Do not place inlet grates for drainage structures under the aircraft so that dropped tools or materials do not fall through the grates (9).

The loading pad will normally be designed with a small concrete pad on one side for utilities. The pads are generally lighted only for security purposes and not with sufficient lighting for nighttime work. Portable lighting can be brought in if there is a need for nighttime work. All fixed objects on the side of the pad should be limited to maximum of 24 inches above the surface. This could vary depending on the aircraft served. However, where large aircraft such as MAFFS C130’s are loaded, the 24-inch limit should be observed between the edge of the loading pad and the OFA limit (18).

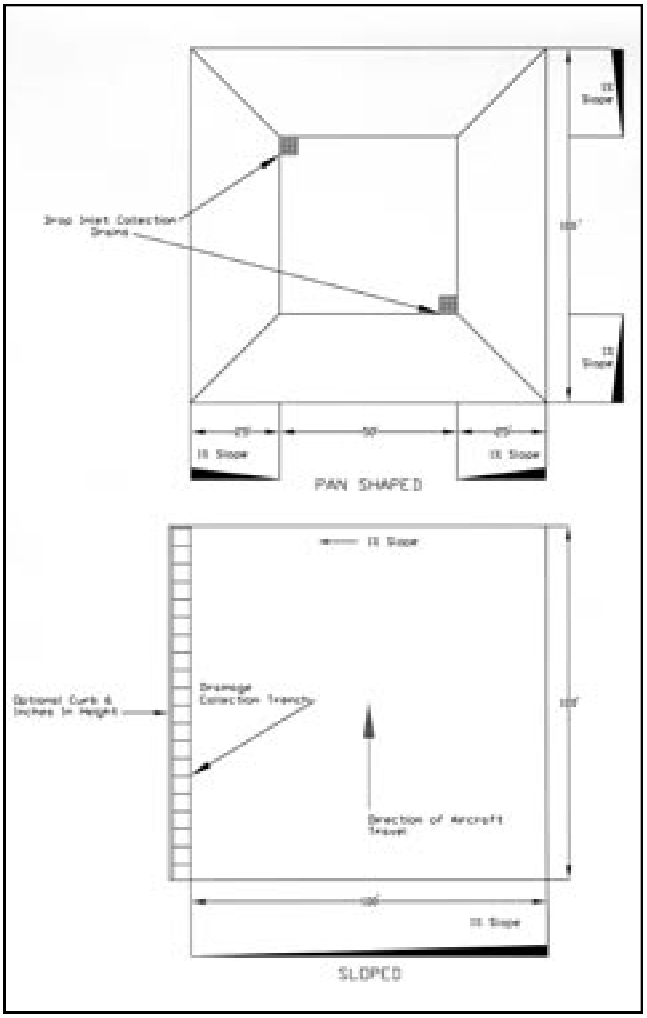

Figure 31—Loading pad configurations (sloped and pan shaped with offset collection drains).

Loading pad utilities

Each loading pad needs to have a retardant delivery manifold and a water hose for aircraft washdown. In addition, it is often desirable to provide a 110-volt electrical outlet, a connection for pump controls, a connection for mass flowmeter readouts, and a communications outlet. At some bases, an electrical outlet for aircraft start cables is required. In some locations additional manifolds may be required for loading water, foam, or other fire suppressants. The utility outlets should have terminal fittings that allow quick connect and disconnect so that hoses, cables, and so forth can be removed and stored indoors overwinter.

The utility outlets are often mounted on a small concrete pad (utility pad) adjacent to the loading pad. They should be protected from forklift or fuel truck damage by concrete-filled bollards or curbs (less than 24 inches high).

Figure 32—Loading pad utilities (San Bernardino, CA).

The retardant manifold should terminate slightly above the utility pad surface (no more than 24 inches) with a quick-connect type fitting such as a “cam lock” fitting. The loading hose should be flexible and skid and abrasion resistant. Hose skates prevent abrasion to hoses being dragged to and from the aircraft for loading retardant.

Washdown/cleanup hoses should be skid and abrasion resistant (high pressure fire hose), and connected to a water source capable of high volumes and working pressures. Install automatic hose reels to help keep hoses neat and eliminate unrolled hoses from being a hindrance to operations. A foot switch should be installed for the hose reel so that the employee can have the hands free to guide the hose onto the reel.

Maintenance Pad

Maintenance may have to be accomplished on “any” pad if the aircraft becomes immobilized (flat tire, engine out, and so forth). However, it is best to provide a specific area that is out of the prop- or rotor-wash of other aircraft; and can collect spillage and other residues, support the weight of heavy aircraft jacks and engine-change equipment, and provide utilities, (such as nightlighting, electrical outlets, and high-pressure washdown water). Spill and washdown water containment and disposal systems are normally needed to meet the requirements of environmental laws and regulations.

During sustained operations fueling may be restricted to specific areas for such reasons as dust contamination prevention, spillage recovery, refueling restrictions, faster refueling responsiveness, or preventing delays to other aircraft waiting for loading pad access. The ramp area or pads where fueling and oiling operations occur may expect fuel or oil spillage. A concrete surface is recommended because petroleum products erode asphalt. Spill containment and disposal systems are required on these pads to meet environmental regulations and laws.

The grades and alignment for the taxilane approaching the pad (and on the pad) should be in accordance with FAA design guidelines (6). The designer should ensure that large airtankers have a 10-foot tangent in the nosewheel travel path on both the approach and departure side of the nosewheel-parking position. This allows the aircraft to be parked with the nosewheel straight.

Lighting should be provided for security purposes in accordance with the base security plan. Working light is typically provided by means of portable lightstands. Provide an electrical outlet for portable lights and tools. Often, a 220-volt outlet is provided at the maintenance pit.

Helicopter Pad

It is necessary to provide separation between rotor-wing and fixed-wing operations with the rotor-wing aircraft downwind. Landscaping can often be used to provide separation. A blast wall may be required where prop wash from large aircraft would affect rotor-wing operations.

Typically, a concrete pad is provided for helicopter operations. Layout and design should conform to the IHOG (11) and FAA design guidelines (10). If unpaved surfaces are used for FATOs, taxi routes, or parking areas consideration must be given to dust abatement that will be sufficient to prevent FOD and brownout conditions. Grass covers work well for this purpose, but must be watered regularly to remain effective (see figures 33 and 34).

Figure 33—Example of a well-turfed heliport.

Figure 34—Example of a paved heliport.

Provide full spill containment where retardant, foam, or other fire suppressant will be loaded.

Light-Aircraft Parking

Parking areas should be paved and have tiedowns for all light aircraft. The light-aircraft parking ramp should provide easy access for pilots to and from the operations building. The structural design should follow FAA design guidelines (6). Use striping to indicate aircraft taxi routes and parking positions.

Figure 35—Light aircraft tiedown and parking area (Klamath Falls, OR).

Off-Duty Parking

To the extent possible, provide secure, off-duty parking for contract aircraft off the retardant base at other locations on the airport. However, when this is not practical, some off-duty parking may be required. Parking areas should be paved.

The structural design should follow FAA design guidelines (6). Use striping to indicate aircraft taxi routes and parking positions. Security lighting should conform to the base security plan. Typically, no utilities are provided to an off-duty parking area.

Aircraft Refueling
Fueling services may be provided off the retardant base, or fuel trucks may deliver fuel to the aircraft onsite. Fuel-spill containment and disposal should be considered when designing loading pad and parking area drainage and containment. Environmental laws and regulations must be followed. For most bases a spill containment plan is required for fuel and oils in accordance with the Spill Prevention, Control, and Countermeasure (SPCC) Regulation 40CFR112 (19).

Chemical Mixing and Loading
The retardant-handling function includes all structures and equipment necessary to receive, store, recirculate, proportion, blend, mix, test, and load retardant into airtankers. It may include storage and distribution of foam concentrate and, sometimes, mixing of foam solution. It also includes facilities needed to handle containment and cleanup of spills. The chemical-handling function is part of any permanent, temporary, and/or portable base facility. The design of an efficient retardant-handling facility requires careful attention to requirements for power and water supply, access for service and supply vehicles of many kinds, containment and disposal of spills of dry and liquid retardant, OSHA requirements, and general maintenance and housekeeping practices. These requirements will ensure a safe and efficient working environment for base personnel and the flexibility to handle all types of retardant with minimal changes to the base.

Design retardant mixing, storage, and output to supply the seasonal, daily, and 2-hour retardant demand. The demand is determined by peak condition (projected or historical load and maximum possible load). To the extent possible flexibility should also be included in the plan to accommodate expanded operations.

Systems and techniques required to move product from storage through mixers and into retardant wet storage vary according to the general nature of the products. Because onsite restrictions and requirements vary so greatly from place to place, bases will vary considerably in design and output capabilities. Consult the retardant supplier throughout the planning and design process to ensure that systems are appropriate for the type of retardant being supplied. However, plans must take into account all types of retardant for future use.

The mixing plant and retardant storage tank farm should be located on one containment area with adequate access for forklifts. Locate the area to minimize the distance to all loading pits. Since all piping that carries retardant must have secondary containment (usually containment trenches), consideration should be given to minimizing the length of the retardant-delivery trench and particularly the amount of trenching requiring airplane-rated grating. The containment area should provide adequate space, utility capacity, and flexibility to accommodate equipment and hardware required for all retardant types currently available, while providing the appropriate equipment and configuration for the type of retardant currently contracted.

Care must be taken when specifying materials for tanks, pumps, piping, fittings, valves, and other parts that will come into contact with retardant. Galvanized steel, brass, bronze, and other metal reacts chemically with retardant to drastically shorten component life. Carbon or stainless steel generally provides longevity for components. Life cycle cost analysis may be needed to determine if cheaper parts can be replaced on a more frequent basis rather than purchasing more expensive components made from a less-reactive metal. While there is some concern over the reaction of polyvinyl chloride (PVC) glue with retardants, it does not appear to be a common problem. Therefore, PVC can be used effectively when conditions warrant.

Concrete working surfaces are preferred for all chemical-handling facilities. The concrete surface should be roughened in accordance with OSHA requirements. Typically a light-broom or a burlap-drag finish is adequate.

Access to the tops of tanks should be by steps with handrails or attached ladders with safety cages rather than by stepladder. Elevated work areas should be minimized. Where they are needed, platforms, walkways, steps, and ladders must be carefully planned and engineered to meet OSHA and structural requirements. They must have sturdy well-supported platforms, grated decks, antislip coatings, and railings for the safety of base personnel. Elevated work areas should provide an unobstructed view of ground operations.

Figure 36—Platform over tanks (JEFFCO, CO).

Designers should consider requirements for sampling and testing as defined in the LA/QA Guide (2), the National Long Term Fire Retardant Requirements Contract (3), and USDA Forest Service Specification 5100-304, Sec. 4.2 (4). Retardants made from dry powders are sampled and tested after mixing. When a batch mixer is used, a 1-quart sample of the mixed retardant is taken while the mixed retardant is being transferred to storage tanks. Wet concentrates can be sampled during transfer from the tanker truck to the base storage provided that recirculation is possible on the truck. In other cases, the concentrate is transferred to an empty (or near empty) tank, recirculated, and sampled. Mixed retardant from wet concentrates are sampled after the blending valve.

Figure 37—Stairway and ladder to overhead decks (Porterville, CA).

Suitable sampling valves will make the job of sampling easier and cause less cleanup.

Provide grates and/or protective covers over pits, drains, recessed plumbing trenches, delivery hoses, chemical storage tanks, chemical mix tank openings, belts, shafts, gears, and elevator chains. Designs must conform to OSHA requirements.

The mix plant should be provided with adequate lighting for night operations such as mixing, cleanup, and repair.

Figure 38—Mixing and storage area night lighting (San Bernardino, CA).

Dry product mixing systems

These products are delivered to the base as a dry powder and are mixed with water in a batch mixer or by eductor. The water supply must be capable of meeting the flowrate demands of the eductor, proportioner, or batch mixer. If the basic supply system cannot meet these demands, a booster pump and a water storage tank may be needed. If a water storage tank is required, it must not be connected directly to the retardant storage tank. Provide an air gap at batch mixers and a install a check valve at eductors. If a facility is being rebuilt, check for connecting lines below grade or piping channels. Eliminate any cross connection that might offer a chance of retardant seepage back into the water line. In order to produce a "certified" retardant product, the water used for mixing retardant must meet potable water standards. Do not use supplies that are murky or contain bacterial contamination.

Eductors—Dry powder, which can be stored in bulk silos, trailers, or semibulk containers, is fluidized by use of compressed air. An adequate compressed-air supply must be made available to fluidize the product. The dry powder and water are proportioned through an eductor. The proper mix ratios are maintained by controlling the vacuum setting of the powder intake side and by regulating pressure on the water discharge side. A water flowmeter is sometimes used to help maintain proper proportioning.

Figure 39—Eductor mixer (Grass Valley, CA).

The expected daily and 2-hour demand rates determine the size of an eductor in terms of discharge gallons per minute. The retardant supplier can provide information on eductor sizing and supply. Mount remote controls for the eductor (mechanical and electrical) at ground level (if possible) to allow personnel to control the mixing operation from ground level. A work platform that meets all OSHA requirements is required where the eductor is mounted on the mix tank.

The powder-supply hose length is a critical factor. The location of the storage silo, bulk bag hookup, or slide trailer parking area should minimize the supply hose length to the extent possible. Consult the retardant supplier for technical assistance.

A small hand-operated crane may be used during mixing operations to support freestanding semibulk containers. A sloped surface can be provided for the container at the loading point so that it is tipped slightly towards the powder exit hole to aid powder flow. The container can be placed on a wooden platform or a pallet so that the backside is about 3-inches higher than the front.

Never submerge the discharge end of the eductor in the retardant tank. Do not add hose or pipe to the discharge tube because the tube will not operate properly under those conditions. Provide a view port and/or access hatch where the eductor is mounted on the tank so that the operator can visually check the mixed product and take required samples. When an eductor is used, it is often discharged into a mix tank. The retardant-transfer system is then used to move the retardant from the mix tank into a storage tank or tanks.

Mixers—Retardant is supplied in bags or containers for mixing with water in a batch mixer. Batch mixers are designed for use with specific products. Ensure that the proper mixer is in place for the product chosen for use at the base. Engines or motors used on batch mixers must be sized to adequately shear and mix the selected product. Consult the retardant supplier for engineering details.

During batch mixing, water is added to the tank to the proper level, usually identified by some type of indicator on the tank or fill gauge; dry powder is measured into the tank in accordance with the manufacturer's instructions while the mixing agitator is running; the mix is blended for the prescribed time; and when sufficiently mixed it is transferred to a tank. The discharge from batch mixers can be tied into the retardant distribution system in a way that permits direct loading of aircraft. The expected daily and 2-hour demand rate determines the number of batch-mixer units needed. Mixer-output capacity compared to peak demand will help identify the volume of retardant storage required. A mixer with automatic flow controls has been designed and can be installed in some cases (12).

Figure 40—Automatic dry powder batch mixer (12) (West Yellowstone, MT).

Figure 41—Dry powder mixing operation batch mixer (Redding, CA).

Three-phase electrical service is required for the mixer motors and the transfer pumps. The transfer pump controls should be operated from the same location as the mixer controls.

Minimize elevated work areas. Where they are needed, they must have sturdy well-supported platforms, grated decks, antislip coatings, and railings for the safety of base personnel. All catwalks, platforms, walkways, ladders, and stairways should be in accordance with the latest OSHA requirements. All mixer controls should be easily visible and accessible to the operator.

Storage should be provided for equipment and tools to be readily available for clearing blockages, fixing leaks, etc. Quality control equipment and sampling points should be handy and readily accessible.

Wet concentrate mixing systems

Wet concentrates (liquid/fluid concentrates) are liquid products with viscosities in the range of 200 to 2,500 centipoises that are shipped to the base in tanker trucks. They are mixed with water as they are pumped into the airtankers by using a proportioning valve. Thus, the mixing and loading operation is one in the same. The mixing/loading pumps should be controlled from a point that has a good line of sight to the aircraft loading point. Critical operating controls for any of the retardant transfer systems should be readily accessible at the mixing point. See appendix D.

Figure 42—Wet-concentrate storage tanks in a spill-containment pit (Stead, NV).

Proportioning valves—Inline mixing of wet concentrates is accomplished by use of a proportioning valve (inline proportioner or blender). Different types of proportioners are used for various types of retardant. The valve is installed between the storage tanks and the loading pumps, but each proportioning valve requires a slightly different plumbing configuration and necessary space. The expected daily and 2-hour demand rate determines the required size of the proportioner in terms of discharge gallons per minute. In order to produce a “certified” product, consult the retardant suppliers for the appropriate proportioner.

Systems can be designed to provide automatic maintenance of equal fluid levels in the water and retardant tanks supplying the proportioner. This helps maintain an equal flow to the blender to minimize the adjustments that must be made to produce a consistent product. Locate proportioners as close as possible to concentrate tanks or drums, water supply points, and the pump to minimize the length of piping and hoses, and reduce friction loss.

Figure 43—Liquid product delivery system with wye blender (JEFFCO, CO).

Figure 44—Inline proportioner, orifice blender (Redmond, OR).

Figure 45—Inline proportioner, Canadian blender (Fort Huachuca, AZ).

Figure 46—Inline proportioner, Vari-blender (McCall, ID).

Check valves—Liquid and fluid concentrate systems require check valves and control valves to prevent the flow of concentrate into the water source or waterflow into the concentrate tank. Install these valves between the proportioner and the supply tanks or water source. Many check valves require a specific physical orientation to ensure they are functioning properly.

Figure 47—Check valves.

Pumps

Selection of the proper pumps for a base is critical to providing proper tank recirculation, material handling, and timely aircraft loading. Typically, one retardant delivery pump is required for each two loading pits. This allows loading one aircraft while the airtanker in the second pit departs and the next tanker is positioned for loading. The choice of electric motors or internal combustion engines to drive the pumps is dependant on the availability and cost of an adequate electric service. Where electric motors are used, it is common to provide a backup pump driven by a gasoline engine. The backup pump can be a portable pump with quick connections in the plumbing for easy hookup when needed or it can be permanently plumbed into the manifold.

The pumping rate for retardant loading should conform to the current contracts for full service bases and aircraft as appropriate. At the time this guide was written, the target retardant delivery rate for large airtankers is 400 to 500 gallons per minute. For SEATs it is 200 to 300 gallons per minute. When considering pump selection, the high viscosity of retardant must be considered. Mixed retardant has viscosities in the range of 50 to 1,000 centipoises while fluid and liquid concentrate can have viscosities in the 200 to 2,500 centipoises range. Fluid or liquid retardant that has set overwinter can have viscosities as high as 10,000 centipoises.

Where possible, utilize electric motors for the primary pump with provisions for gasoline-engine driven pumps for backup. Electric pumps should be equipped with a pulley/belt drive system so that pumping rates can be adjusted by installing different pulleys. The transformers and breaker panels required to operate an electric pump system have a much higher initial cost than support systems for internal combustion engines. However, electric pumps generally require less maintenance and are much quieter. Installation of low-voltage remote control off-on buttons or deadman switches at the end of the loading hose permits shutting the electric pump down before closing the loading valve, thereby greatly reducing shock-loading on the piping system. In all cases, an internal-combustion engine-operated pump or generator should be available as an emergency backup system.

Figure 48—Electric- and gasoline-powered retardant pumps with vibration isolating flexible hose (San Bernardino, CA).

Inline throttle controls should be installed at the outlets of gasoline engine powered retardant delivery pumps. This system reduces engine revolutions per minute in response to reduced flow as the loading valve is closed. This reduces hammer effects. Vibration of gasoline-driven engines should also be isolated from the rest of the distribution system.

An effective method of reducing hammer effects and vibration is to use short sections of rubber hose for both suction and discharge connections. This requires regular suction hose, or a similar hose that will not collapse under vacuum.

The fittings used to connect the pump to the piping system should be the quick-disconnect type to allow fast replacement in case of a breakdown.

Figure 49—Hose with quick disconnect fittings.

Again, regardless of the type of primary pump drive, a spare backup pump driven by an internal combustion engine should be available. The best arrangement is to have the backup pump preconnected and ready to operate on a moment's notice. If a water tank is the principal source for the batch mixer or the eductor, have another spare pump on hand to ensure a continuous water supply. If a retardant recovery tank is used for off-loading aircraft, a system will be needed for pumping that retardant back into the aircraft again. Portable pumps are often used for offloading and for reloading from the recovery (offload) tank. Off-loading retardant from the aircraft requires hose that will not collapse. Suction hose and PVC pipe are commonly used.

Tanks

Storage of water and retardant must be adequate to ensure that the demand determined during the planning phase is met. Vertical or horizontal tanks in a variety of capacities are currently in use. It is generally considered most efficient to install several smaller horizontal tanks to provide adequate storage while providing flexibility for operations and possible future changes. However, where very large volumes of storage are needed, vertical tanks with conical bottoms are sometimes more efficient (see figure 50).

Standard plans and specifications for 10,000-gallon water tanks, 10,000-gallon retardant storage tanks, and a variety of "cross-link" polyethylene off-load tanks are available from the USDA Forest Service, Missoula Technology and Development Center, Facilities Program.

The height of silos and storage tanks, including catwalks and working platforms, must comply with airport setback and building height limitations, which may be part of glideslope clearance requirements. Consider clearance requirements for wing tips and tail surfaces of airtankers when locating tanks. Follow FAA guidelines (6).

Figure 50—Conical bottom storage tank with debris trap installed at tank outlet.

Retardant storage—Several smaller tanks are preferred over a single large tank for the following reasons:

1. Retardant can be transferred and selected tanks emptied for winter maintenance.

2. It provides for recirculation and sampling of each lot of material as it is received.

3. Recirculation tends to be more efficient in a small tank.

4. Individual tanks can be emptied systemati cally to allow for cleaning, inspection, and maintenance.

5. Environmental impacts of a leak will be less than for a larger spill, and spill containment can be accomplished faster.

6. Breaching of one large tank can result in the total loss of retardant stock while multiple tanks offer some assurance of retaining some of the stored retardant.

7. The size of the containment structure (125 percent maximum tank size) is less than for larger tanks.

All tanks must be located inside a containment structure that will control runoff of spilled retardant and maintenance and washdown residues (9).

The design should consider ease of access for interior cleaning and repair. If vertical tanks are being considered, a tank with a conical bottom will facilitate recirculation and cleaning more readily than a flat-bottom tank. A conical tank also simplifies complete emptying of the tank. If horizontal tanks are used, they should be sloped very slightly toward the tank outlet for more complete emptying and cleaning.

Install traps at the tank outlets to prevent dropped tools and debris from being pulled into and damaging the pumps. Some trap designs allow for trap cleanout even when the tank is full.

The bottom of the tank should be above the inlet of the transfer pump. The installation of a sump in the tank bottom will permit total utilization of the stored retardant. Outlets through the tank wall are less desirable than bottom outlets as they contribute to buildup of cake or solid deposits on the tank bottom. Most products contain ingredients that settle out during storage. This may adversely affect the quality of the retardant produced. Suitable recirculation must be available to assure that this material is remixed into the stored liquid. (See the section on retardant tank recirculation for detailed information.) Plumb the storage tanks to permit both recirculation and transfer of stored materials.

Secure tank access and discharge openings with a locking mechanism. Locate outlets from storage tanks in the bottom of the tank, or as close to the bottom as is feasible. The tank outlet is commonly connected to the manifold with a flexible hose to provide flexibility for vibration and seismic shock. All outlets and tank valves should have a minimum 4-inch diameter.

Use check valves to keep retardant from flowing into or out of tanks in an uncontrolled manner. Provide tap points (sampling valves) in each tank so that retardant samples can be collected and checked for conformance with established viscosity and salt standards. If a thickened product is stored, consider some type of recirculation system within the tank itself.

Install exterior gauges, sight ports, or petcocks on all tanks to permit quick determination of retardant inventory at any time. Sampling ports can be included with the fittings for the sight tube.

Install the tank outlet valves so they can be secured against accidental or other unplanned openings. Paint storage tanks a light reflective color to minimize mixed retardant heating and reduce condensation within the tank. Care must be taken when specifying materials for tanks, piping, fittings, valves, and other parts that will come into contact with retardant. Galvanized steel, brass, bronze, and other metals that react chemically with retardant should not be used unless it is determined to be more cost effective to use cheaper parts that can be replaced on a more frequent basis rather than purchasing more expensive components made from a less reactive metal.

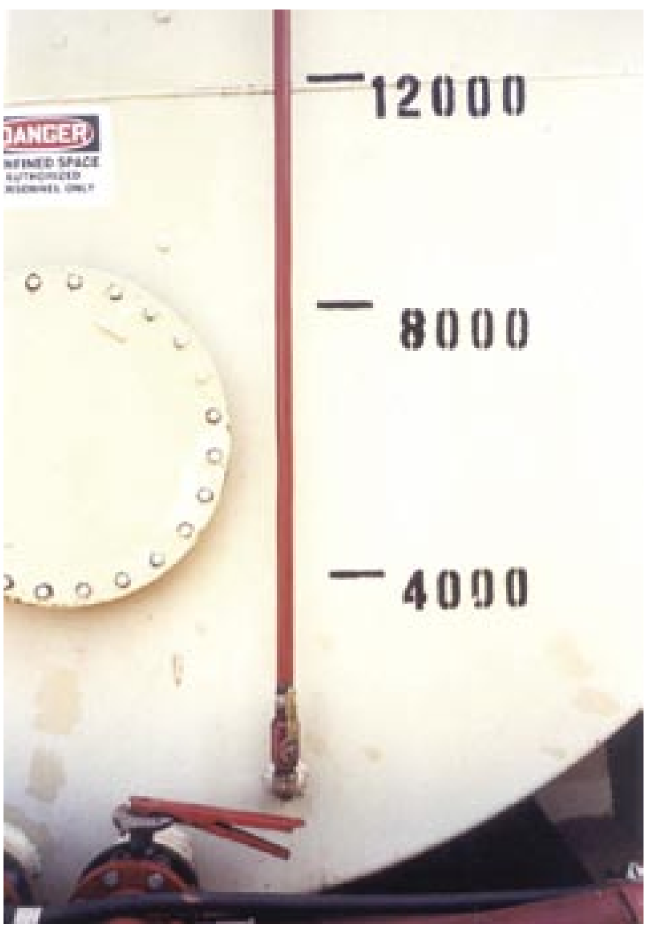

Figure 51—Tank liquid level sight gauge.

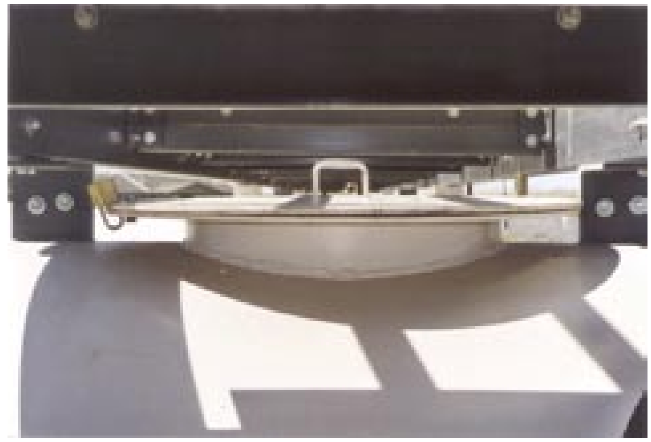
Figure 52—Chemical storage tank access, locking cover.

Retardant tank recirculation—Wet concentrates must be recirculated regularly to ensure that all components are in the mixed retardant in the proper amounts. After dry powder retardant is mixed through eductors or in batch mixers, it is transferred to storage tanks and recirculated regularly. The goal is to ensure there is a complete overturn and rotation of stored liquid. The liquid must sweep the tank bottom to minimize buildup of solids. Automation of recirculation controls may be desirable for products that require frequent recirculation (7).

The key to success in any mixing and recirculation arrangement is to maximize pump performance. To accomplish this, obtain the manufacturer's performance curves for the recirculation pump and use them to determine the point of maximum efficiency for the preferred flow rate. Consider the effect of viscosity on pump performance. Determine the corresponding lift value (again from the curves) and set the pump, using a pressure gauge and throttling valve, to obtain the required backpressure. A more complete discussion and example of the use of the pump performance curves is contained in appendix E. Remember that the pump size and power, the tank size and geometry, and the retardant type will all determine how well a particular system will be able to recirculate stored product. Pumps used for recirculation can often be used to move retardant between storage tanks and to offload tanker trucks of wet concentrate.

Water—Either horizontal or vertical tanks of the appropriate size may be specified. Install a number of smaller tanks with connecting manifolds where flexibility is important. If the tanks may be used in the future for retardant storage, they should be in the containment area.

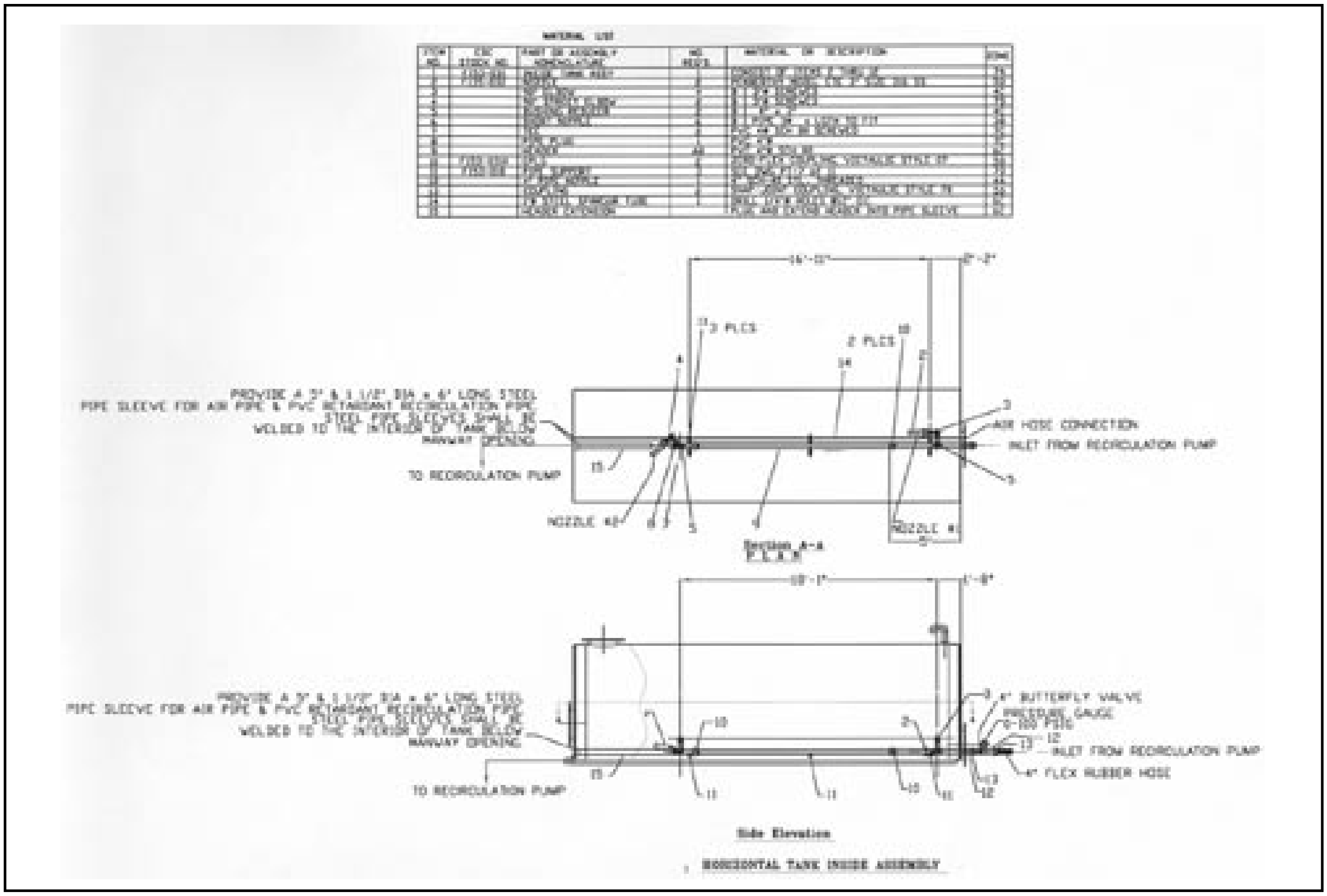

Figure 53—Wet concentrate storage tank recirculation plumbing.

Locate outlets from storage tanks in the bottom of the tank, or as close to the bottom as is feasible. The tank outlet is commonly connected to the manifold with a flexible hose to provide flexibility for vibration and seismic shock. All outlets and tank valves should have a minimum 4-inch diameter.

Figure 54—Water storage tank (Ely, MN).

Use check valves to keep water from flowing into or out of tanks in an uncontrolled manner. Install backflow prevention when direct connections to potable water systems are used.

Figure 55—Backflow prevention valves.

Use an automatic or float valve at the water tank inlet to control water level in the tank.

Figure 56—Automatic water valve.

Offload—The airtanker base manager will try to avoid airtanker offloading whenever possible. However, when offloading is necessary, all offloaded product must be stored separately from other retardant and should be used as soon as possible. Offloaded retardant can be contaminated and the likelihood of degradation of the gum with resultant loss of viscosity is increased. A 3,000- to 6,500-gallon tank is typically installed within the containment area for offload storage. Determine the tank size from historic or anticipated need for offloading aircraft. It can be plumbed to accept a portable pump for offload and for reload. Use cam-lock-style fittings so the pump can be switched from offload to reload mode quickly. Tank access and discharge openings must be able to be secured with a locking mechanism for security purposes. Tanks are typically constructed from steel or cross-link polyethylene.

Mass flowmeters

An accurate and dependable means of measuring quantities of fire retardant loaded on airtankers is required to ensure that safe aircraft load limits are not exceeded, to help optimize payloads, and to ensure that just compensation is paid to retardant contractors. A mass flowmeter must be utilized for all aircraft loading applications when required by the agency (8).

Mass flowmeters must be installed in the loading lines in such a way that each planeload of retardant is quantified and product density is monitored. The meter should have readouts at the plane, at the tank farm, and in the operations room. A printer should record the data from the mass flowmeter for each plane loaded.

Figure 57—Mass flowmeter.

Valves

Several types of valves are required to adequately control mixing, transfer, recirculation, offloading, and loading retardant. Since each base has its own unique plumbing arrangement, no universal plan is possible for valve configuration. An efficient plumbing layout with well-located valves can permit efficient operation and can reduce the number of pumps needed. By properly configuring the valves and pumps, one of the retardant delivery pumps can be used for recirculation. This is particularly useful where a backup gasoline pump is permanently plumbed into the system. The gasoline engine can be used for recirculation in order to keep it running well. By adjusting the valve setting, it can easily be switched to retardant delivery if one of the primary pumps fails. Retardant flow control valves are usually specified as adjustable butterfly valves with a narrow disk design with self-centering for positive shut off, and an infinitely variable handle.

Valves having several parts made of dissimilar metals or alloys are sensitive to corrosion and erosion by retardant chemicals. Use soft-seated valves rather than metal-seated valves to increase valve life. In most cases the use of “low-end” valves with more frequent replacement is more cost effective than the use of stainless steel or other “high-end” valves (24).

Install an adequate number of valves in the distribution system to permit isolation of a storage tank or a disabled pump for repairs. Valves must also be installed so that there is flexibility to continue operations when any pump or tank is out of service. Technical advice from engineering specialists and experienced tanker base designers and operators should be sought when developing or modifying the plumbing.

Figure 58—Quarter-turn loading hose valve.

Loading valves on the end of the hoses are usually some type of quarter-turn hose valve. They can be opened and closed quite rapidly, without risking valve damage. However, they can cause a severe hammer effect that can result in rupture or failure of hoses, pipes, or fittings. A pressure relief valve is often required to minimize this problem. Low voltage shut-off switches or dead-man switches may be installed at the loading valves so that the retardant flow can be shut off by shutting down the pump prior to closing the loading valve.

Check valves are used to keep retardant and water separated. They are also used to keep retardant concentrates separated from mixed retardant. This is especially important for systems designed for use with liquid or fluid proportional mixing blenders.

A sampling valve, located just below the midpoint of the batch mixer, will allow sampling during mixing, transfer to base storage, or loading of an airtanker from the batch mixer. Locate other sampling valves on the pumps used for recirculation and loading. If this is not practical, install sampling valves into short sections of hose that can be located where needed in the recirculation and loading lines, and near the loading valve. Stainless steel valves provide a long life. In some cases it may be cost effective to install brass valves and replace them frequently. Galvanized fittings should NOT be used, since the galvanizing reacts chemically with retardants.

Pressure relief valves are often necessary in the retardant delivery piping to reduce potential damage from hammer caused by closing loading valves while the pump is still running, and to reduce pressure buildup from retardant manifolds being heated by direct sunlight. Locate pressure gauges at critical points in the piping so that personnel can easily monitor the pressure being developed in the pipes and fittings.

Figure 59—Pressure relief valve (San Bernardino, CA).

Manifolds

Distribution piping for permanent installations should be carbon-steel pipe, but can be aluminum or PVC for temporary bases. If hammering caused by closing loading valves is a problem, consider surge suppression devices and/or install bypass valves in the system. Select pipe size based on the type of pipe and pump performance, the viscosity of the fluid being pumped, and the distance from the pump to aircraft loading points. Pipe that is 6 inches in diameter is usually adequate for most permanent installations. The larger pipe reduces friction loss for the high viscosity fluid and cushions any hammer effect that is developed. Piping should be adequate to deliver the required gallons per minute to the aircraft. For the best results, an engineering analysis of the proposed piping arrangement is recommended. One possible way to minimize this source of hammer damage is to install surge tanks or accumulators in the piping systems. When training the loading crew, emphasize the need to close valves slowly or to shut the pump off first if a hose-end pump control system is in use.

Positive thrust blocking of pipe may be necessary at points where abrupt changes in direction occur. Thrust blocks are usually necessary when plastic pipe is used because plastic pipe tends to expand and contract more than aluminum and steel. Plastic pipe also degrades, becomes brittle, and changes shape when exposed to direct sunlight.

Piping that carries retardant should not be buried, but placed in a concrete trench covered with steel grating. This allows the pipe to be removed quite easily for repair or replacement and also provides some protection from direct sunlight. These trenches should be designed to be a part of the containment and disposal system for spills and washdown water.

Hoses

Where possible, plan for separate loading hoses so that retardant, water, and foam are not loaded through the same hoses. Flexible "suction" hose is typically specified for use as loading hose. The end that connects to the retardant delivery manifold should be equipped with some type quick-connect fitting for easy installation and removal where the hoses are removed and stored each winter.

Loading hoses are heavy when full of retardant and large sizes are difficult to handle. In order to reduce wear and abrasion and to increase handling ease, support the hose on one or more hose skates.

Figure 60—Loading hose and hose skates (San Bernardino, CA).

Figure 61—Loading hose and hose skates (JEFFCO, CO).

Chemical Delivery and Storage

Timely and efficient delivery and storage of retardant, foam, and other fire suppressants is critical to the retardant base. When designing a base, build in the maximum flexibility to allow access and storage for all type of chemicals that might be used. While the construction or improvements must provide adequate access and storage for the type of chemical currently being supplied, it is often possible to provide space, working surfaces, and storage that can easily be converted if a different product is supplied. The access route and offload parking should be designed for a truck to pull through without backing up.

In addition to the information that applies to any retardant chemical storage, there are some additional cautions and considerations for temporary air bases. Storage is usually provided in some type of flexible-walled portable or bladder tank. While these are designed to resist some abuse, care will extend their life and minimize environmental impacts caused by spills. Protect the bottoms of the tanks with a ground cover and provide some kind of leak and/or spill containment.

Wet concentrate

Liquid and fluid concentrate is shipped to the base in tanktrucks of varying configurations then stored in base retardant-storage tanks until used. Consult the retardant suppliers to determine the trucks that might be used for delivery. The design vehicle should be that vehicle which requires the most curve widening to accommodate off tracking. Access for the tanker truck to the storage tanks should be based on that design vehicle.

Arrange base concentrate storage so that the concentrate can be transferred from the tanker truck to an empty tank. Plan so that the entire truckload can be transferred to a single storage tank. The product is transferred between storage tanks using a transfer pump. The transfer pump is often also used for recirculation of the retardant storage tanks. Camlock fittings and butterfly valves are used to increase ease and speed of transfer operations. The retardant storage tanks, offload area, and transfer plumbing must be constructed to provide secondary containment for spills and washdown water. Containment must be sized to accommodate 125 percent of the capacity of the largest tank.

Dry powder

Dry powder products are delivered to the base by airslide trailer or semitrucks. Retardant suppliers can provide information on the configuration and size of trucks and trailers that will be used. Airslide trailers are used for bulk powder shipments in lots of approximately 22 tons. Dry powder in an airslide trailer may be elevated or blown into silos of 35- to 50-ton capacity or into a semitrailer that serves as the product storage unit. Provide a paved area adjacent to the mix plant for long term parking of the slide trailer. There should be easy access for the tractor unit to unhook from and hook to the trailer. Provide compressed air piping and/or an electrical outlet at this parking pad. Additional parking of a second trailer may be needed. Critical operating controls for any bulk transfer system should be readily accessible at the mixing point.

Silos should have a conical bottom and a vibrating system to loosen powder and keep it from adhering to the sides. They should also be equipped with a dust collection system to reduce or eliminate fugitive dust. Pads for silos and product trailers should be concrete and should include secondary containment for washdown water. Consider the prevailing winds and blowing dust from dry-product transfer when locating silos. Do not locate silos in areas of prop wash.

Containerized retardant is packaged in 1/2-ton to slightly over 1-ton bags or bins. Product delivered in these semibulk bags can be offloaded with a forklift. Provide a smooth hardened access road from the truck offload area to the storage area and from the storage area to the mix plant. Asphalt pavement is recommended.

Figure 62—Dry powder bulk bins (Alamogordo, NM).

A secure storage area that is large enough for product rotation, provides adequate access to all containers, and access for forklifts is required near the mix plant. At some sites, covered storage or a storage building will be necessary. Provide surfacing that facilitates easy clean up of spills. Store the bags in one or two layers until ready to use.

While it is acceptable in many areas of the country to use outside storage for dry powder during the fire season, during the winter it is preferable to have inside storage. When this is not possible, provide covered storage under a shed or individual container covers. Storage under tarps may not prevent moisture from accumulating on the containers and working its way into the product. Since semibulk containers, pallets, and drums must be moved with a forklift, adequate pull in/backup space is required in the storage area.

Foam and other fire suppressants

These chemicals are normally supplied in 5-gallon buckets or 55-gallon drums. Design the access and pull through parking for unloading to accommodate a standard highway-legal semitruck. Pallets and drums can be offloaded with a forklift. A paved surface should be provided for the forklift operation.

In most cases, foam concentrate and other fire suppressants will be stored in a warehouse or other enclosed storage building. The retardant base may load these products into a SEAT or function as a reload point for helicopters or ground engines. The containers should be located where they are easily accessible when needed, but will not interfere with the retardant mixing and loading operations.

Figure 63—Foam concentrate containers.

Use shelving to prevent overstacking. Drums that are 55 gallons or larger may require secondary containment. Certain products cannot be stored with other products, so separate storage must be planned. Protect containers from exposure to extremes of weather and sunlight. Information on storing and handling these products can be found in *Foam vs Fire, Class A Foam For Wildland Fires, NFES 2246* (5).

Foam and other fire suppressant concentrates may create cleanup problems. Small spills of a cup or so can be washed away with water. However, a disposal container that can be removed from the area must be provided for large spills. Provide for a small stock of sand, sawdust, or kitty litter to absorb the remainder of the spill. Do not wash away large spills.

Eyewash and Drench Shower

Eyewash and drench showers that meet OSHA requirements must be provided within 50 feet of any point where retardant is handled. Only an eyewash is required at each pit (no drench shower). However, locate eyewash and drench showers at the tank farm or warehouse that is easily accessible from the loading pits. Provide portable eyewash units at the loading pits when the base is active.

Figure 64—Emergency eyewash station (San Bernardino, CA).

Containment

The recovery of spillage and washdown liquids containing fuel and oils must meet all environmental laws and regulations for handling, storage and disposal. In most cases, all washdown water must be contained and directed to a clarifier or sand/oil separator that will remove oils and other hydrocarbon products. Consider each site's stormwater drain location, containment, and filtration in regards to local, State, and Federal stormwater laws and aquifer acts. Secondary containment of at least 125 percent of the capacity of the largest tank must be provided for the mixing plant, tank farm, and retardant delivery lines. Configure the containment such that all components including piping can be visually inspected and easily accessed for maintenance or repair. Use open grates (designed for anticipated loading) to cover trenches, sumps, or other secondary containment components.

Multiple systems may be required where physical size or layout of the base does not allow a single cost effective system. Permitting requirements for wastewater treatment and disposal is a critical consideration. Sampling requirements for wastewater disposal may include separate sampling ports in the collection and disposal system.

The holding area (reservoir, ponds, and so forth) must be large enough to contain all expected washdown, spillage, and any natural precipitation captured by the airbase collection system. *Management of Airport Industrial Waste*, FAA AC #150/5320-15 (13) contains some useful information on this subject.

Storage Building

Locate a storage building to be accessible from the chemical handling facilities for battery charging and testing and repair activities. There should be a place to store a forklift, replacement parts, spare fittings, hoses, and pumps. Consider other base equipment when designing the building to ensure there is adequate space. Provisions should be made for the wintertime storage of hoses, pumps, mass flow meters, outside fire extinguishers, and any remaining support equipment. Because this facility will be relatively close to the mixing area, provide an appropriately sized first aid kit and eyewash/eye protection station. If feasible, the building should have running water and suitable plumbing, modern lighting and ventilation systems, a telephone, the proper number and type of electrical outlets, and heating. It should be configured for ingress, egress, and parking of heavy equipment and vehicles, such as staketrucks, forklifts, and other maintenance-type equipment. Include a workbench in the storage area. A separate section can be set aside for quality control test equipment required for quality control and related recordkeeping.

Typical storage building size allowances are:

Bases over 1,000,000 gallons per year	1,500 to 2,000 square feet
Bases less than 1,000,000 gallons per year	1,000 to 1,200 square feet
Reload bases	400 to 800 square feet

Figure 65—Storage building (JEFFCO, CO).

Appropriate storage and handling requirements for hazardous materials must be defined. Provide an area for the storage of contractor-related items. Often the contractors require space for storage bins, structures, or containers. These may include spare aircraft parts, engine assemblies, oil drums, spare tires, auxiliary power units, and trucks or vans that are mobile maintenance shops. Meet all accessibility standards.

Figure 66—Storage building with contractor work and storage area included (Porterville, CA).

Operations Building

The base operations office is the communications center and focal point for the airtanker base and its design should receive priority consideration. The building should provide adequate space and be properly configured and equipped to allow personnel to function without restriction and stress—especially during periods of peak activity. Soundproofing and acoustics are important items to consider, either when constructing a new building or remodeling an existing one.

Figure 67—Retardant base operations office (Moses Lake, WA).

Typical space allowances are:

Bases over 1,000,000 gallons per year	3,500 to 5,000 square feet
Bases less than 1,000,000 gallons per year	3,000 to 3,500 square feet
Reload bases	1,200 to 1,500 square feet

The airport facility, where the airtanker base is collocated, may also be utilized as a mobilization/demobilization point when incident management teams, crews, miscellaneous overhead, equipment, supplies, and so forth, are temporarily staged, mobilized, or demobilized via government aircraft or commercial airline. Contingency planning for expanded operations and facilities should include preinstalled telephone lines, additional radio console positions, airport or local staging and mobilization facilities, transient personnel standby shelters, and appropriate supplies and equipment storage. The contingency plan should consider the impact on the retardant base operations. Plans should detail requirements for keeping contingency operations separated from the base operations.

The building must be fully accessible and provide separate and equal facilities for men and women. Winterization of the building must be considered in all aspects of building design where the building will not be used during the off-season.

Operations room

Locate the operations room to provide unrestricted visibility of the entire mixing plant, ramp, and runway. Where possible, the configuration should also provide a view of the access gates to the site for security purposes. If the desired visibility cannot be provided directly, the operation should be designed with a camera system that provides such visibility. The camera system can also provide security surveillance as well as operations visibility.

Figure 68—Retardant base operations (Moses Lake, WA).

The operations room should be far enough away from the retardant mixing plant and the ramp to avoid as much noise as possible. It should be properly lighted with shielded fluorescent-type lighting fixtures (as opposed to the incandescent type). The building should be furnished and configured so that expansion and contraction of operations can be achieved for routine and maximum activity. Adhere to energy conservation rules and regulations. Glass panels should be reflective, slanted, and capable of glare dispersion.

Provide adequate soundproofing, including sound-absorbing glass.

An observation tower should be planned only if accessibility requirements can be met.

Pilot briefing—Design an area within the operations building for the base manager to do pilot briefings. The area should have a “stand up” counter for writing and sufficient wall area for aviation maps.

Figure 69—Pilot briefing area (Helena, MT).

Figure 70—Pilots' readyroom (San Bernardino, CA).

Offices

Use agency guidelines to size offices for the base manager, assistant base manager, leadplane pilot, air attack officer, and contractor's personnel. It is important for the base manager to have a separate office with a lockable door. Other offices can be combined or separated as appropriate for base operations.

Provide space for the retardant and aircraft contractors as well as other contractors who work at the facility. There should be a contractor workstation where the contractor can do paperwork. Service should be available for a contractor-provided phone and computer. This space is often provided as a separate office space that can also be utilized as a conference style room when not needed by the contractors. Separate the contractor and agency work areas so that the contractors (and agency personnel) can have private conversations and work space. This is important in order to maintain a contractor/COR (or inspector) relationship.

Dayroom (pilot's readyroom)

Provision should be made for a separate, comfortable, and quiet area for on-duty pilots. When planning the size of the pilot readyroom, estimate the maximum number of pilots and associated personnel who may effectively utilize the lounge at any given time.

As with the operations office, the pilot readyroom should be located close enough to the ramp area for convenience of the pilots and to provide quick response—but far enough away to avoid as much of the associated noise and activity as possible. Cooling, heating, and lighting should be provided for comfort.

The main lounge area should include as a minimum, couches, chairs, a reading table, and an office-type table or desk. A bulletin board should be furnished to display hazard maps of the area, departure routes for aircraft, military aircraft routes throughout the area, safety alerts, etc. Provide a blackboard and magazine rack or bookcase for training materials. Provide vendor pilots access to a private area with a telephone. A television monitor and video cassette recorder should be included to provide opportunities for pilots and base personnel to view training and/or safety video tapes as well as being a source of entertainment. Telecommunications provisions should include radio, telephone, and Internet access. Consider a satellite dish or television cable hookup. In some cases a separate pilot readyroom building is provided to serve this need. However, if it is possible to include the dayroom in the operations building it improves communication and coordination and reduces the total floor space required to provide the same functionality.

Kitchen

Adjacent to the pilots' readyroom provide a kitchen area that includes a range, microwave, refrigerator, icemaker, and a sink with hot and cold water. Insure the kitchen is large enough to accommodate kitchen table(s) and chairs. Design adequate space for vending machines.

Quiet rooms

Normally no provision for overnight sleeping is provided at an airtanker base. However, individual compartments (quiet rooms) for resting should be provided. Quiet rooms for resting of on-duty pilots should include separate areas for men and women.

Restrooms

Include men and women's restrooms that are sized to meet peak demand. A single unisex restroom is only appropriate for a base where less than five people will be stationed even during peak demand.

Showers—Provide enough showers for transient pilots, transient personnel, and base personnel to wash-off retardant or other chemicals and contaminants. Typically, showers are included inside the restrooms. However, in some cases, one or more separate shower(s) and dressing area(s) may provide a better layout.

Lockers—A sufficient number of lockers must also be provided for the anticipated workforce. Typically, lockers are included inside the restrooms. However, in some cases, one or more separate shower(s) and dressing area(s) with lockers may provide a better layout. Specifications for lockers can be obtained from the USDA Forest Service Missoula Technology and Development Center, Facilities Program.

Utility room

A separate utility room is normally designed into the operations building for HVAC equipment and the hot water heater. The room should be adequately sized to provide easy access for service, maintenance, and replacement of equipment. This room should neither be designed for nor used for storage of paper products, cleaning equipment, and so forth. Access to the room can be from the outside or from an interior hallway.

Telecommunications

Modern telecommunications hardware such as VHF-FM and VHF-AM radios, fax machines, personal computers and associated software, modems, laser printers, public address systems, typewriters, copy machines, multiline telephones, satellite telephones, and cordless telephones will enhance base office operations and both inter/intra base communications. Consider these items as standard equipment requirements. Flexibility in design is needed to accommodate future use, upgrades, and new technology.

Figure 71—Telecommunications room (San Bernardino, CA).

Laundry

Provide laundry facilities so any contamination is not carried offsite and that facilities are available for pilots and transient crews that have flight and duty limitations and infrequent days off. Where space is critical and low use is expected, a stackable washer dryer is an option. Arrange for a commercial service to provide uniforms or laundry service if onsite laundry facilities are not possible.

Figure 72—Laundry facilities (San Bernardino, CA).

Storage
A separate storage room is commonly included in the operations building. This room provides space for fax and copy machines, as well as shelf space and cabinets for storage of files, paper goods, office supplies, and the like. The space can be finished using typical office finishes and electrical, telephone, and data outlets. This permits the room to be used for expanded operations during emergency operations. Adequate environmental control is required if computers or copier equipment is to be installed.

Heating/ventilation/air conditioning (HVAC)
Adequate cooling, heating, and ventilation of the facility are essential requirements to provide a comfortable environment for personnel who may spend long hours in the building in all types of weather. Pilot stress-relief is a major factor to consider.

Flexibility needs to be built into the HVAC system to provide cost-efficient and energy-efficient operations when one or two people occupy the building (such as in the winter) and when it is fully occupied at the level of peak activity.

Electrical service
In the event that the primary electrical power source fails, a backup electrical system, such as a gas- or propane-powered generator should be available. A backup generator can be wired into the building to provide emergency power for critical areas of the building. Design electric panels so that critical loads are located in one panel that can be powered by a smaller generator than would be required to power the entire building. If a generator is not included, then configure the electrical service equipment so that a portable generator can be tied into the building to power the critical areas of the building.

Figure 73—Retardant base backup electric generator system (Porterville, CA).

Shade Structures/Shelters
Provide some form of protection from the sun for personnel involved in the chemical mixing operations. The protection could be part of the rest area and have a covered patio-type structure with benches and a solid wall to act as a windbreak. It is also important to provide a shaded outdoor area for pilots and other base personnel to relax or congregate. The area should be sheltered from the prevailing winds and should be large enough for the anticipated number of personnel during peak operations. A properly designed and constructed space can often help reduce congestion and stress inside the operations building during peak activity.

Figure 74—Shaded rest area (Chester, CA).

Utilities
Site utilities must be sized to meet current and future peak demands. Use the base planning documents to provide information on future uses that will need to be connected to the site utilities. Coordinate with utility companies throughout design to ensure that the most efficient system is built that meets their requirements, regulations, and standards. Site utilities should be sized to provide adequate service when the type of retardant or mixing method is changed.

Water
The reliability of the water source is critical in airtanker base design. Loss of this single element will result in total-base shutdown. An adequate storage capacity must be planned and an alternate source should be available in case of unreliability or failure of the primary retardant air base water source. The water source may be an existing municipal or commercial source or may be provided onsite through installation of a well. If neither source is feasible, storage for a hauled-in water supply may have to be considered. In order to determine quantity requirements, the estimated supply capability in gallons per minute,

based on a 12-hour day, must be determined. Depending upon water source output capacity, a water storage facility may have to be planned to adequately handle the base requirements.

Design the base water delivery system to include, at a minimum, several small-diameter hookups for 1-inch or greater garden- or firehose-type lines. This will provide water for an exterior shower or to “hose off” in the event of a broken or leaking retardant hose or spill. Include aircraft washdown provisions.

Consider use of booster pumps where pressure from the source is not adequate. Storage may be needed if the delivery rate is insufficient.

Water used for retardant mixing must meet potable water standards or the retardant will not be a “certified” product.

Electrical service

Loss of the primary power source can affect the water supply, communications, mixing, loading, and so forth. Operational areas must plan adequate backup through gas/diesel generators, gas/diesel pumps, larger storage capacity, and increased water/mixed retardant storage. In the event that the primary electrical power source fails, a backup electrical system, such as a gas- or diesel-powered generator should be available. Install transfer switches at appropriate locations in the electrical distribution system so that generators can be hooked in quickly when needed.

Sewer

Size the sanitary facilities to meet peak demand. Dispose of normal domestic wastewater and sewage through a municipal or public sanitary district system, if possible. If not, disposal through a septic tank and either a leaching field or seepage pit may be the viable alternative, if locally acceptable. In some cases, a storage system for pumping and offsite disposal may be required. The domestic disposal system design should be based upon the average number of personnel on duty and anticipated visitors during operations.

Washdown water from the base containment system is another liquid waste requiring disposal. The liquid will contain water, retardant chemicals, and small quantities of fuels, oils, and greases. Volumes of containment system wastes can be determined directly from water volumes consumed during aircraft equipment and ramp retardant spillage cleanup, abort, and washdown operations. The system for disposal of containment wastes will vary according to local authorities. Some authorities allow disposal into a municipal or public sanitary district system after passing through a sand oil separator or clarifier. Onsite evaporation basins may be required with offsite disposal of solids.

Figure 75—Evaporation lagoon.

In some instances, a total holding facility with offsite disposal would be required (9). Never recycle wastewater of any kind to mix retardant.

Gas

Either LP or natural gas should be provided to the base. Coordinate with the local provider to ensure the most efficient distribution system is designed to meet all applicable codes, requirements, and standards.

Storm drains

Drainage is a key element in the design of a retardant base. Storm drains must tie into the site and/or airport drainage system and be designed to minimize the use of pump stations. Use channel gates or other control valves to separate the stormwater system from the spill-recovery system and from the washdown water disposal system. A 3-way gate or valve system is often used to allow the base operator to direct stormwater runoff to the stormwater disposal system and to open the stormwater system when the base is closed; direct water coming from the washdown water collection system and base containment structures to a sand/oil separator for disposal of wastewater; or direct spills to a containment tank or basin.

Telecommunications
Good communication links are vital on the airtanker base. Efficient communications systems must be provided at different locations and in varying levels of service. Ground-to-ground radio communication may be required between the airtanker base office and the responsible dispatching office, and between the airtanker base office and the mixing/loading area. Telephone communications can also be used between these locations as a primary or supplemental system. Ground-to-ground radio communication may be required for aircraft ramp control or the contact support operations such as fuelers.

Air-to-ground radio communication will be required to facilitate airtanker base and airtanker operational needs. Agency telecommunications specialists should plan antenna location and communications equipment. Antenna location and height must conform to FAA requirements and normally will require FAA approval (6).

Other onsite communication equipment requirements may include:

- Public address system and/or local intercom service
- Data cables, computers, and printers
- Mass flowmeter data cables, readouts, and printers
- Time clock (punch in and out) for dispatch and recording of flight time of aircraft.

A backup system for ground-to-ground and air-to-ground communications is a necessity in case the primary system is lost. Clear concise communication is the safety lifeline in every component of wildland firefighting.

Security
Due to the potential for sabotage of aircraft and chemical retardant stock, vandalism of facilities, or theft of equipment and supplies at airtanker bases; fencing, lighting, and security are absolutely necessary. Consider a separate area for public viewing with appropriate fencing. Restricted areas, such as loading, mixing, and ramp areas can be partially controlled by appropriate signs. The base and airport security plans should dictate requirements for access control, lighting, signing, fencing, and gates. Closed circuit cameras or other monitoring equipment may be necessary. Follow agency guidelines for planning and design of all security features (20).

Fencing and gates
Restricted areas, such as loading, mixing, and ramp areas, must be secured with appropriate fencing. This will normally require a chain link fence at least 6-feet high. The fence may be on the perimeter of the base property or it may be installed to separate the restricted areas of the base property from areas where other personnel or the public will be allowed. The base and airport security plans will dictate requirements for access control, fencing, and gates. Automatic gate controllers may be required. Additional cabling or electrical service points may be required for gate controllers.

Figure 76—Base fencing and security gate (Helena, MT).

Contact airport facilities personnel to determine any requirements for gates that allow access to the tarmac area. Sometimes, all gates accessing the airport proper must meet specific standards or requirements.

Access control
The base and airport security plans will dictate requirements for access control. Access through gates and doors may be controlled by punch pad or card key locks. In some cases, recording key card locks are required. Additional cabling or electrical service points may be required for gate and door controllers.

Signing
Restricted areas, such as loading, mixing, and ramp areas can be partially controlled by appropriate signs. The base and airport security plans should dictate requirements for restricted-area signing. Exits to buildings that lead to

restricted areas must be properly signed. Signs should be used to clearly delineate what areas are restricted to personnel with various levels of clearance. If an escort is required for the public or agency personnel that do not have proper clearance, signs should be posted to clarify the requirement.

Lighting

The base security plan should dictate site lighting level requirements and requirements for photovoltaic units or motion sensor units. Provide security lighting around buildings, chemical mixing and storage areas, and aircraft parking areas. If cameras will be used for remote monitoring, lighting levels may need to be increased. Security lighting must conform to FAA requirements (6) and should be included with site lighting in the submittal for FAA approval.

Landscaping

Landscaping can provide for a clean, aesthetically appealing facility that will result in good public image, as well as enhance relations with other airport users and managers. To be effective as an outdoor use area, landscaping must also help provide shade from the sun and screening from wind.

Figure 77—Entry sign and security fence at a well-landscaped retardant base (Troutdale, OR).

Outdoor use areas can provide an effective place for crew separation. They can structure the physical and mental environment to facilitate communications and to reduce stress by providing a recreational place for both physical exercise and mental relaxation. It is best to avoid plants that produce allergy-activating pollens, fruit that attracts wasps and other pests, and root systems that disturb plumbing and foundations. The local agency landscape architect should participate in planning and design of landscaping to provide an atmosphere conducive to pilot and other crewmember stress reduction.

Landscaping will marginally assist in reducing and providing shielding from the noise of jet engine runup. Landscaping should also be used to help reduce noise emissions. Minimum landscaping should be provided to reduce or eliminate erosion and dirt or dust blown by aircraft and windy conditions that are prevalent at air bases for dust abatement and FOD reduction. Grass, paving, or suitable rock can often reduce or alleviate the problem.

Visitor facilities

The needs for public visitor controls will depend on the location of the base. Some bases are at airports where present security and policy allow only authorized personnel in the proximity of the base. However, where base location is easily accessible and visitors can be expected, signs and fences should be provided that clearly direct their activity. Base security is a priority, but public information should be provided to the extent possible.

Generally, public visits fall into two categories. One is the individual or party that comes seeking information. They should be directed to some point so as not to disturb key personnel active in the base operations or enter restricted areas. The other concerns people who come to view the aircraft loading and takeoff operations during fire activity. It is recommended that a suitable parking and viewing area separated from restricted areas be provided and properly signed. For public areas, accessibility standards must be met and sanitary facilities considered.

An information board containing base history, types of aircraft being used, and so forth may be provided. This will reduce questions to base personnel and will enhance relations with the public and the media.

Figure 78—Aircraft viewing area signing (Santa Barbara, CA).

Site Amenities

Each site needs certain site amenities. These amenities should be designed to fit the character of the base, provide operational efficiency, and conform to agency and FAA standards.

Flagpole

Most bases will be equipped with a standard flagpole. Typically an aluminum flagpole 20- or 30-feet tall is provided. The location and height normally must be reviewed and approved by FAA to ensure there is no infringement on glideslope planes.

Dumpster

Onsite trash disposal must be provided. Commercial trash-disposal services may be available or the service may have to be provided by the airtanker base personnel. All containers should be designed to provide adequate capacity during peak fire periods, including visitor needs.

All trash-disposal containers must be covered and adequately secured to the ground surface to prevent loss from aircraft prop-wash and to avoid filling with rainwater or scattering of contents by the wind.

Where possible, locate dumpsters outside the restricted area fence to allow easy access by the trash hauler. Consult the trash service provider to help determine location. Where dumpsters are provided, a suitable concrete pad should be designed. A fence may be placed around the dumpster in some locations where vandalism or public access is a problem.

Figure 79—Secure trash disposal containers.

Sidewalks

Sidewalks can be designed to the agencies typical construction detail. The width should be at least 3 feet except where public access or accessibility must be provided. In those cases, the sidewalks should be 5-feet wide. Ramps and accessible curb cuts should meet accessibility standards.

Signing and striping

Airtanker bases have many activities taking place during large operations. To ensure safe, secure, and efficient operation, proper signs and markings should be provided. A variety of signing and striping are needed at a retardant base. When establishing a new base or modifying an existing base, a master signing and marking plan should be established to include aircraft ground control, security restrictions, and areas of NO TRESPASSING, NO SMOKING, WARNING, and HAZARDS. Signing standards will be different for the airfield-side and the vehicular-traffic side. The appropriate FAA, OSHA, AASHTO, Manual of Uniform Traffic Control Devices (MUTCD), Americans with Disabilities Act (ADA), and agency requirements must be met (14, 20, 22, and 23).

Figure 80—Radio frequency sign.

Figure 81—FAA standard signing for radio frequency (San Bernardino, CA).

A base entrance sign that conforms to agency standards should be placed at the vehicle entrance to the site. An entrance sign that conforms to FAA standards should be placed at the aircraft entrance point. Equipment, valves and controls should be properly signed, tagged or marked. Follow OSHA guidelines for safety marking and signing. Follow current security guidelines for signing and marking restricted areas.

Figure 82—Safety signing.

Vehicle traffic control is a must. Signing should start at the access roads to the airtanker base and clearly state any special provisions, such as “Admittance Restricted to Authorized Personnel Only.” If public access is authorized, signing showing direction should include visitor parking instructions and reserved or employee parking areas. Special signing and gates may be required for access points to the chemical mixing and storage areas and the aircraft ramp areas. To properly direct personnel involved in the base operation, structures and utilities should be properly marked and signed.

Many types and kinds of aircraft with varying missions can be expected to enter the base operations area. Proper signing and marking of taxiways, loading pads, tie down and refueling areas ensure a safe and efficient traffic flow to and from the base operations area. Marking of the various aircraft areas requires careful consideration of type and size of aircraft.

When preparing a signing and marking plan for aircraft, consult the local airport authority to satisfy compliance with the local and FAA requirements (14). This ensures that proper traffic patterns are established and communications are compatible between authorities involved in directing of aircraft.

A nosewheel guide stripe painted on the pad will aid pilots and can help prevent damage to the pavement caused by wheel lock when a pilot pivots the aircraft on one wheel to execute a sharp turn. The radius of the nosewheel guide stripe should conform to the recommended radius for the largest aircraft anticipated.

Figure 83—Retardant base striping (Klamath Falls, OR).

Windsock

A windsock may be required at some bases. The location and height of the windsock support should conform to FAA standards and clearances.

SITE LIGHTING

Retardant base planning should include lighting for functions that occur at night as well as security lighting. At a minimum, lighting should be provided for the ramp and loading pits, the chemical retardant mixing platform and storage tanks, other hazardous areas, the base office and storage, and parking areas. If possible, parked aircraft should be well lit. The base security plan should dictate site lighting level requirements and requirements for photovoltaic units or motion sensor units.

For parking areas, roadways, and security lighting around buildings, the use of high-pressure sodium fixtures is recommended. For work areas where a whiter light is needed, such as the retardant mix plant, metal halide fixtures are recommended.

Lights may be mounted on a variety of standard light poles or attached to buildings Light pole height must take into consideration airport safety zones as well as lighting level requirements. Placement of lights must not interfere with flight operations due to height or glare. FAA approval of lighting levels and fixture heights is normally required.

SECURITY

At the time of publication, standards for aviation facility security are undergoing major revisions for several agencies. Follow specific agency direction for security plans and requirements.

TEMPORARY/PORTABLE BASES

Create site development plans for sites that will be used repeatedly for airtanker operations. The process and considerations are the same as for permanent bases (Section II) except that consideration should be given to minimize fixed capital improvements. Portable mix plants and spill containment systems can be utilized where use will be sporadic. Where use will be consistent, plan fixed improvements that meet all standards for the type and size of operation. The analysis should consider the ability to adequately contain spills and washdown water to meet environmental laws and regulations.

There are a variety of mobile and portable retardant bases and services available through the retardant suppliers. These are fairly complete units that are transportable to a fire or potential mixing site by truck, trailer, or helicopter—depending on the type and the specific need. They come with a kit that contains retardant storage tanks, valves, hoses, and pumps. The kit allows for several configurations to take best advantage of the needs dictated by the features of the selected site.

In some cases, the chemical mixing, storage, and loading equipment used for permanent bases has been scaled down for use with the lower waterflows common to many portable operations. These scaled-down systems are ideal for use with smaller volume helicopters and SEATs. Because of the location of portable bases in remote areas, environmental concerns may be more obvious and immediate than at a developed retardant base.

Check valves and other backflow prevention devices are required to prevent contamination of the water source. A ground cloth with sandbag or dirt berms should be placed under mixing, storage, and loading equipment to contain possible spills of retardant or foam concentrates. In some instances it may be necessary to support "temporary/mobile" facilities at an existing airtanker base. This potential should be pre-identified. Temporary/mobile facilities are available from emergency rental agreement sources (3). They can be prepositioned at a central location and ready for dispatch when the need arises.

OTHER FIXED WING OPERATIONS

Single Engine Airtanker (SEAT)

SEAT operations and facilities are covered in the Single Engine Airtanker Operations Guide (17).

Figure 84—Single engine airtanker (Stead, NV).

Operations at a permanent base

Where SEAT operations are anticipated at a permanent base, provisions for separation of the aircraft from large airtanker operations should be planned. An area for SEAT loading should be identified (possible one of the airtanker loading pads) that will provide adequate separation from other operations. The loading area should have provisions for loading SEATs at the prescribed rate or should provide space for a small temporary plant to serve the SEAT operation. Space for pilots, SEAT manager, management and staffing personnel, chase rig, temporary plant, retardant storage, and other needs identified in the Single Engine Airtanker Operations Guide should be planned into the permanent facility.

Temporary facilities

Follow the provisions of the Single Engine Airtanker Operations Guide (17).

Smokejumper

Where smokejumper operations are anticipated at the same location as a permanent retardant base, provisions for separation of the aircraft from large airtanker operations should be planned. A separate area for smokejumper staging and operational administration must be planned.

Light Aircraft

Light aircraft will operate at most retardant bases. A separate parking area with tiedowns should be planned into all permanent retardant bases. The parking area and tiedowns should accommodate the type and size of aircraft currently in use for air attack, leadplane, and other administrative operations. Space for pilots and other administrative personnel should be planned into the permanent facilities. The location of the parking area should allow movement of personnel to and from the aircraft without traversing the retardant operations and loading areas. Provide for safe fueling of light aircraft on the base or at the FBO facility.

Passenger and Cargo Loading/Unloading

Retardant bases are often utilized for passenger or cargo operations. Retardant base layout should identify areas that will be used for cargo and passenger marshalling and manifesting. The area for passengers or cargo loading/unloading and parking area should be large enough to accommodate large commercial buses and 18-wheel trucks without having them backup to turn around. The area needs lighting for both security and safety during night operations.

An area should be identified for check-in, weigh-in, manifesting, recordkeeping/transmittal, and HAZMAT (fusee, chainsaw fuel, and so forth) collection. Some of these activities are conducted within a shelter and some outside, depending upon the nature of the structure and weather conditions. This area should be located so as not to impinge upon other operations (retardant base control, retardant operations, and so forth). Since most passenger/cargo operations are of a temporary nature, a large travel trailer or motorhome may be adequate. At a permanent air base consider a concrete pad for a mobile office with prearranged hookups for telephone, radio, public address, computer, electricity, water, and sewer. A separate building, or part of the operations building could be used for this function too.

Locate the standby area near the deplane/ embarkation area or the ground transport area. This area should be supervised from the processing office. Access to and from aircraft must be strictly controlled. Standby areas should provide relief from the environment (sun, wind, cold rain, and so forth). Tents or other temporary types of facilities may be used. Potable liquids and sanitation facilities (restrooms, port-a-johns, and so forth) must be provided. Plan areas for temporary storage of cargo that is awaiting transport. Safe, all-weather access for the cargo transporting ground vehicles must be provided.

ROTOR-WING OPERATIONS

A helicopter specialist should be involved in the planning and design of facilities for rotor-wing operations. Adequate separation from fixed wing operations is a critical consideration of planning and design. Rotor-wash can cause problems for personnel working on or around aircraft and can create FOD if separation is not adequate. Guidance for facilities and operations can be found in the Interagency Helicopter Operations Guide (*IHOG*) (11) and FAA Advisory Circular Subject Number 150/5390-2A (10). The airport authority and local agencies should be consulted to determine restrictions on takeoff and landing, fueling, external load restrictions, and other impacts. Base permits and/or leases should include rotor-wing operations as well as fixed-wing operations.

Rotor-wing aircraft, operating from a heliport, use a takeoff and landing area (cleared area) containing a FATO, which is a defined area over which the final phase of the approach maneuver to hover or landing is completed. The same area is also used for the takeoff maneuver. The FATO surface shall be capable of producing ground effect.

When more than one FATO is provided and simultaneous same direction (side-by-side) diverging operations are to be conducted, a center-to-center separation distance of at least 200 feet shall be provided. The illustrated takeoff and landing area is sized for helicopters with a rotor diameter of less than 55 feet. See agency requirements for specific helicopters.

Retardant Operations

Helitankers or Type II helicopters equipped for retardant operations may be staged at a permanent base and may be operated from a permanent or portable retardant base.

Where helitanker operations are anticipated at a permanent base, provisions for separation of the aircraft from large airtanker operations should be planned (11). An area for helitanker loading should be identified (possible one of the airtanker loading pads) that will provide adequate separation from other operations. Rotor-wash and FOD impacts on personnel working around aircraft and other areas of the base must be considered. Provisions must be made to ensure large airtanker prop wash and FOD does not impact the rotor-wing operations.

Figure 85—Helitanker at San Bernardino, CA.

The loading area should have provisions for loading helitankers at the prescribed rate or should provide space for a small temporary plant to serve the helitanker operation. Where helicopter washdown will occur, containment and wash-water disposal must be planned. Consider the issues of prop wash, pilot and personnel movement, vehicle access, and fueling.

A fuel tender will accompany contract helicopters. A parking area with adequate spill containment must be planned at a location that meets fire code and other requirements for fuel-tender parking.

Space for pilots, the helicopter manager, management and staffing personnel, chase rig, temporary plant, retardant storage, aircraft and vehicle parking, and other needs identified in the *IHOG* (11) should be planned into the space and utility design of a permanent retardant base.

Foam or other fire suppressants are typically needed at staging areas for helitankers and Type II helicopters. Storage of the product must be planned into the base facilities. Helitanker and type II operations at a temporary base should follow the *IHOG* requirements (11).

Other Rotor-Wing Operations

Helitack, helishot, passenger, and cargo operations are often conducted at permanent retardant bases. Type II and Type III helicopters are also frequently staged at a permanent retardant base. Separation of the rotor-wing operation from fixed-winged operation is critical. Many of the considerations listed in Section IX (A) Retardant Operations, must be included in planning for other rotor-wing operations.
In addition, the planners and designers must consider the need for cargo delivery and sling-load operations. Space and facilities for helishot or helitack crews may also be required. The retardant base plan should ensure that the base can accommodate the planned operations in accordance with the *IHOG* (11).

APPENDIX A
GLOSSARY

Air Base—A base of aviation operations, usually located on or surrounding an airport. Some of the types of air bases used in fire suppression include:

> **Air attack base—**An air base managing a variety of firefighting aircraft, including an air-attack aircraft.
>
> **Airtanker base—**An air base specializing in fixed-wing transportation of firefighting retardants and chemicals.
>
> **Fixed-wing air base—**An air base specializing in the management of fixed-wing aircraft, which may or may not include airtankers.
>
> **Helibase—**An air base specializing in the management of rotor-wing aircraft.
>
> **Helitanker base—**An air base specializing in rotor-wing transport of firefighting chemicals.

Aircraft approach category—A grouping of aircraft based on 1.3 times their stall speed in their landing configuration at their maximum certificated landing weight.

Airfield—See **Airport—Airside facilities**

Airport—A transportation complex serving aircraft, passengers, cargo, and surface vehicles. It is customary to classify the components of an airport into two major categories with interface facilities between them as:

> **Airside facilities or "airfield"—**That portion of the airport on which aircraft operations are carried out. The airfield principally consists of areas for aircraft takeoff, landing, taxiing, parking, loading, service, and so forth.
>
> **Landside facilities—**That portion of the airport serving passengers and cargo, including processing, holding and storage areas, surface transportation, and parking, as well as administrative and crew standby facilities.

Airside/landside interface facilities— Passenger access **gates, forklifts**, and loading manifold **outlet ports** are examples of interface facilities.

Apron or "ramp"—A defined area, on a land airport, intended to accommodate aircraft for purposes of loading or unloading passengers or cargo, refueling, parking, or maintenance.

Blast fence—A barrier used to divert or dissipate jet blast or propeller wash.

Bollard—A barrier constructed by installing a vertical steel pipe in a concrete footing and filling it with concrete.

Building restriction line—A line that identifies suitable building area locations on airports.

Deck—The airside facilities or airfield of a heliport or an airport. (See Airport—Airside facilities.)

Eductor—A mechanical device used to blend dry powder retardant into a water stream to produce a mixed retardant product.

Entrainment—The process to draw in and transport (as solid particles or gas) by the flow of a liquid.

Fixed base operator (FBO)—The provider of airport services such as fueling, communications, mechanics, and other pilot services.

Foreign object damage/debris (FOD)—Loose debris on the airfield that might cause aircraft damage or personal injury when projected by wind, propeller, or rotor-wash..

Guar gum—A gum consisting of the ground endosperm of guar seeds that is used as a thickening agent.

Helibase: See **Airbase: Helibase**

Helicopter final approach and takeoff area (FATO)—A defined area over which the final phase of the approach maneuver to hover or land is completed and from which the takeoff maneuver is commenced.

Helicopter takeoff and landing area—The cleared area containing a FATO.

Helicopter taxi route—A cleared right-of-way for taxiing between a takeoff and landing area and a parking area. A taxi route may or may not include a taxiway. (See also: Obstacle free area.)

Helipad—A surface used for parking helicopters. It may be located inside or outside of the FATO or the takeoff and landing area.

Heliport—An airport developed for, and restricted to, rotor-wing aircraft use.

Helitanker base—see **Airbase—Helitanker base.**

Large aircraft—An aircraft of more than 12,000 pounds maximum certificated takeoff weight.

Light aircraft—An airplane of 12,000 pounds or less maximum certificated takeoff weight. Also known as small aircraft.

Loading gate—A controlled access/egress portal between a holding area and an aircraft loading pad.

Loading manifold—Plumbing for the distribution of liquids to be loaded into aircraft.

Mixmaster—A person responsible for the mixing operations at a retardant plant.

Modular Airborne Firefighting System (MAFFS)—A portable system designed to install in a C-130 aircraft to convert it to an airtanker. It is normally used for National Guard Aircraft.

National Interagency Fire Center (NIFC)—The interagency center for fire suppression activities throughout the United States, located at Boise, Idaho.

Object free area (OFA)—A two-dimensional ground area centered on runways, taxiways, and taxilanes which is clear of above-ground structures, vehicles, parked aircraft, or other objects except for objects that need to be located in the area for air navigation or aircraft ground maneuvering.

Obstacle free zone (OFZ)—A 3-dimensional volume of airspace above the airport defining the areas of runway, inner-approach and inner-transition which are to remain clear of all objects except for frangible visual navigation aids that need to be located in the OFZ because of their function.

Pad/pit/gate position—A specific parking place for an aircraft to load/unload, refuel, washdown, tiedown, or do maintenance, and so forth. The surface should be prepared to support the weight of the aircraft, capture and recover any spillage, provide access for, and support all service vehicles and activities. Pads may be adjoined to form an apron or ramp.

Plant manager—The person in charge of a retardant plant; usually, but not necessarily the mixmaster.

Ramp or Apron—A defined area, on a land airport, intended to accommodate aircraft for purposes of loading or unloading passengers or cargo, refueling, parking, or maintenance.

Ramp manager—A person in charge of the aircraft parking, loading, and refueling areas of an air base.

Retardant base—A base of operations to mix, store, and transport firefighting chemicals. The terminology is commonly used in conjunction with aerial application operations, but, may also apply to ground-application operations. The area of reference includes the retardant plant, the aircraft handling facilities, and support workstations.

Retardant plant—A processing plant for firefighting chemicals.

> **Chemical manufacturing plants—**Plants that combine and package firefighting chemical concentrates (liquid or powder) for use at chemical mixing plants.
>
> **Chemical mixing plants—**Plants that mix, store, and load firefighting chemical concentrates for application.

Runway—A defined rectangular surface on an airport prepared or suitable for the landing or takeoff of airplanes.

Runway type—A runway use classification related to its associated aircraft approach procedure, such as visual, nonprecision instrument, and precision instrument.

Single engine airtanker (SEAT)—A small fixed wing aircraft with one engine used for aerial application of firefighting retardants and chemicals.

Spall—To break off in chips, fragments, or slabs.

Taxiway—A defined path established for the movement of aircraft from one part of the airfield to another.

Taxilane—The portion of the aircraft apron or ramp area used for access between taxiways and aircraft parking positions (pads).

Taxi route—See **Helicopter taxi route**.

Turning radius—The radius of the arc described by an aircraft (pivot point, usually locked main landing gear, to furthest extension, usually wing tip or tail) in making a selfpowered turn, usually given as a minimum.

APPENDIX B
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Note:
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APPENDIX D
RETARDANT BLENDING CONCEPTS

Fire Retardant Blending Fundamentals

The USDA Forest Service Technology and Development Center (SDTDC), San Dimas, CA evaluated methods that could precisely maintain the proper retardant mix during aircraft loading operations. The following summarizes the methods that were considered. The information presented is to provide a better under-standing of blending theory and what can be done if a problem should arise. The key to proper blending is to maintain the pressure upstream of the proportioning devices constant. Referring to figure D1, as long as P1 and P2 remain constant during fluid proportioning, the proper retardant blending will be maintained.

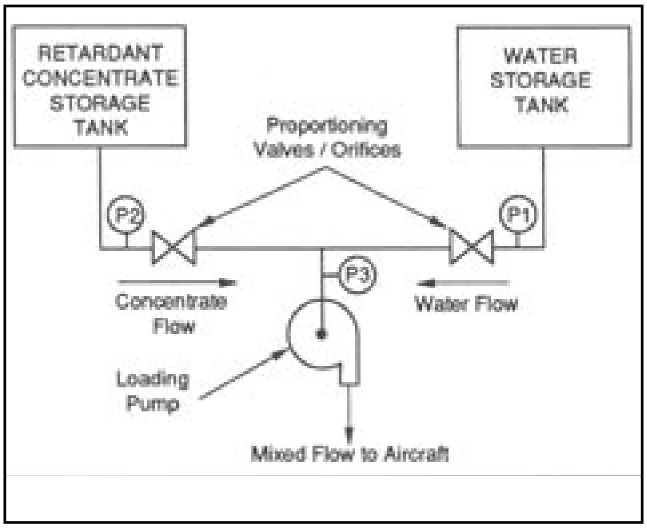

Figure D1—Maintaining pressures P1 and P2 constant ensures proper blending.

To balance a system requires planning. Following are some basic things to think about when planning your blending and loading system:

If the liquid level in each loading tank remains constant during proportioning, blending will be maintained constant. (See figure D2.)

If the change in liquid level in the concentrate storage tank equals the change in liquid level in the water tank, fluid proportioning will remain constant. (See figure D3.)

As long as pressure upstream of the proportioning valves can be maintained constant during loading operations, proportioning will remain constant. (See figures D4 and D5.)

Constant Head Tanks

Using the schemes given in figures D2 through D5 as a basis for design, the best features of each can be realized by the use of tanks that maintain a constant blending/loading pump suction head. This concept is illustrated in figure D6. Constant head tanks will usually require the addition of pumps to a facility and an engineered design.

Use of the Micro Motion Flowmeter to Control Blending

Currently, most Forest Service operated airtanker bases are using a Micro Motion Flowmeter[R] to measure the amount of retardant loaded into an aircraft. The meters have the capability to continuously monitor the specific gravity of the blended retardant as well as the weight of the retardant delivered to the airplane.

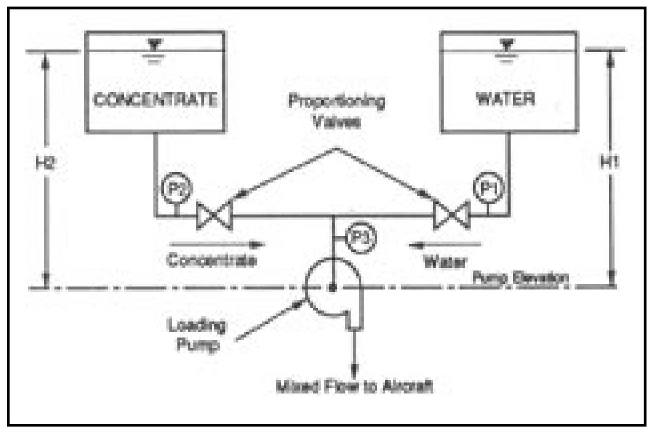

Figure D2—Maintaining the liquid levels in each tank constant during blending assures P1 and P2 will remain constant.

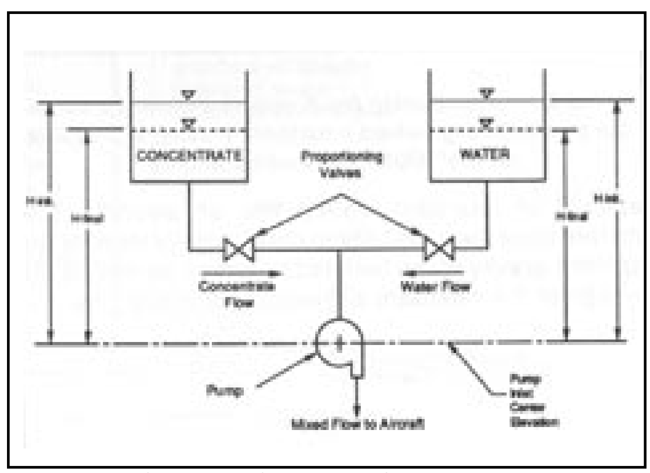

Figure D3—If the rate of change in fluid level is equal in each tank, proportioning is constant.

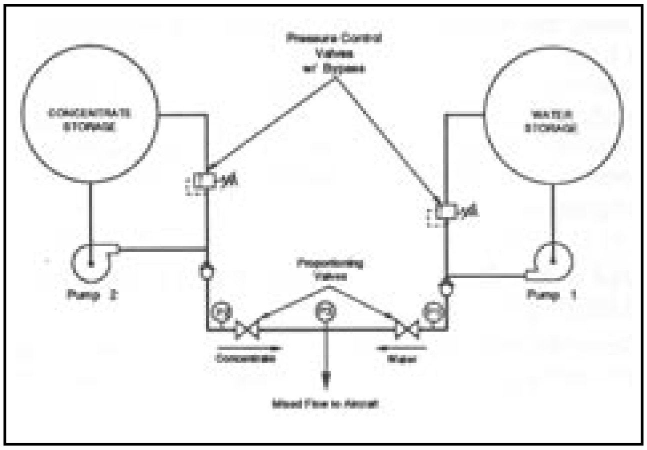

Figure D4—Maintaining the pressure difference across the proportioning valves constant by use of pressure control valves.

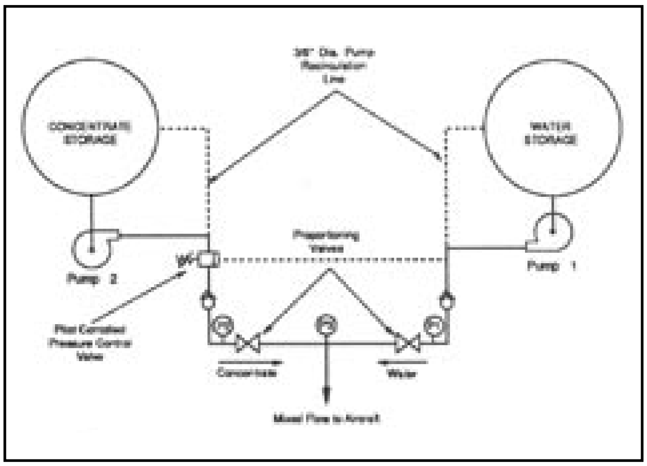

Figure D5—Maintaining the pressure difference across the proportioning valves constant by using a pressure control piloted by water pressure.

It is SDTDC's understanding that these meters can be used to control blending by the addition of a manufacturer provided electronic circuit board that will modulate a pair of motor-operated valves located in the lines upstream of the loading pump. By modulation of these valves the desired specific gravity of the mixed fluid can be precisely maintained by the meter.

Also, it is our understanding that these devices can be retrofitted to automatically provide a pre-programmed amount of retardant to each aircraft and shut down the loading pump once the meter indicates the aircraft is fully loaded. If this additional control can be coupled to a microcomputer system located in the base office in a manner that will allow a database containing the allowable loads for each contract airplane to control loading operations, then the base can simply call up the desired aircraft in the computer and send the loading information to the flowmeter.

This flowmeter-operated system, if feasible, would have the advantages of maintaining the specific gravity of the mixed retardant at an optimum value. This optimum value could result in significant cost savings by assuring that the salt content of each load contained only the required amount—and no more. Also spillage of retardant due to aircraft tank overfill should be virtually eliminated.

To complete the implementation of such a system, it may also be feasible to feed back the meter readings directly into computer software, which then would record each load and automatically calculate the costs associated with the aircraft and the retardant. This would both save base personnel time and eliminate bookkeeping errors.

A conceptual schematic of how such a system would operate is shown in figure D7. SDTDC has no plans at this time to develop this type of system. It is offered here only for consideration of what may be possible in the future to make base operations simpler.

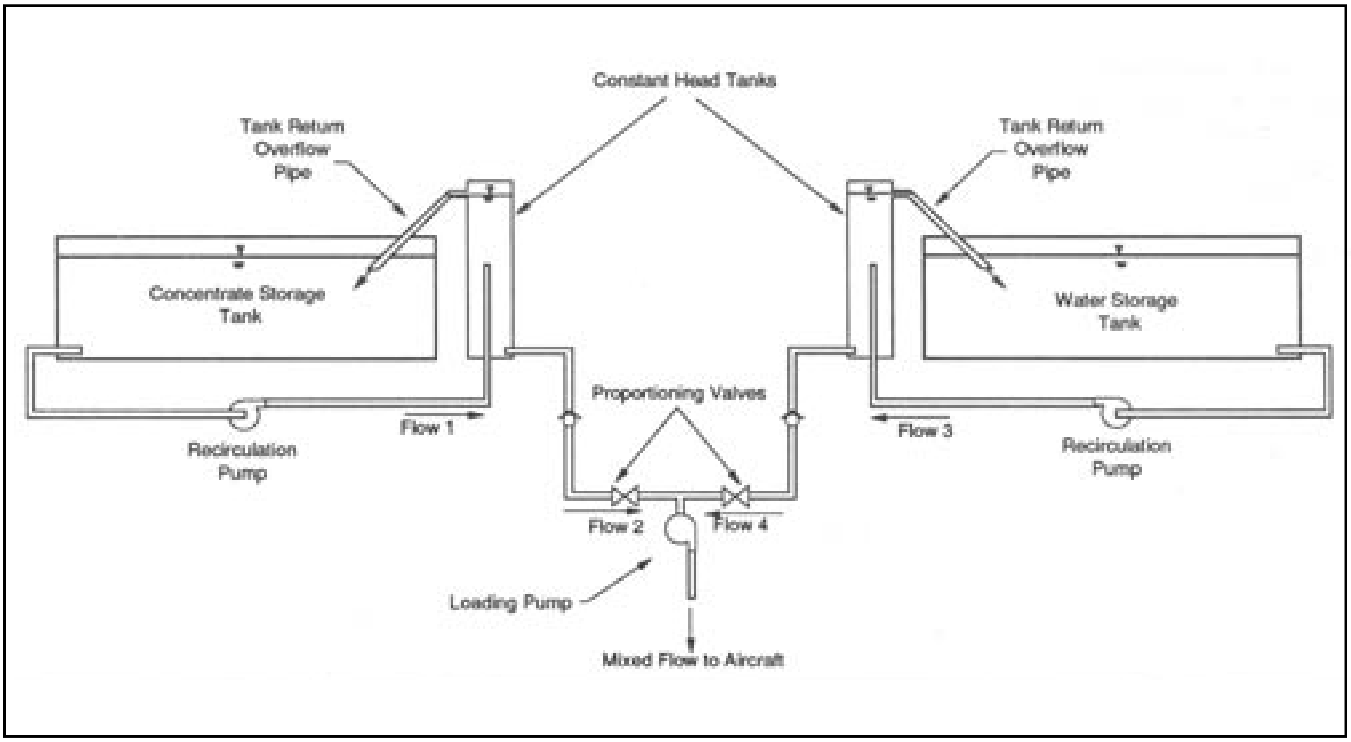

Figure D6—Constant head tank.

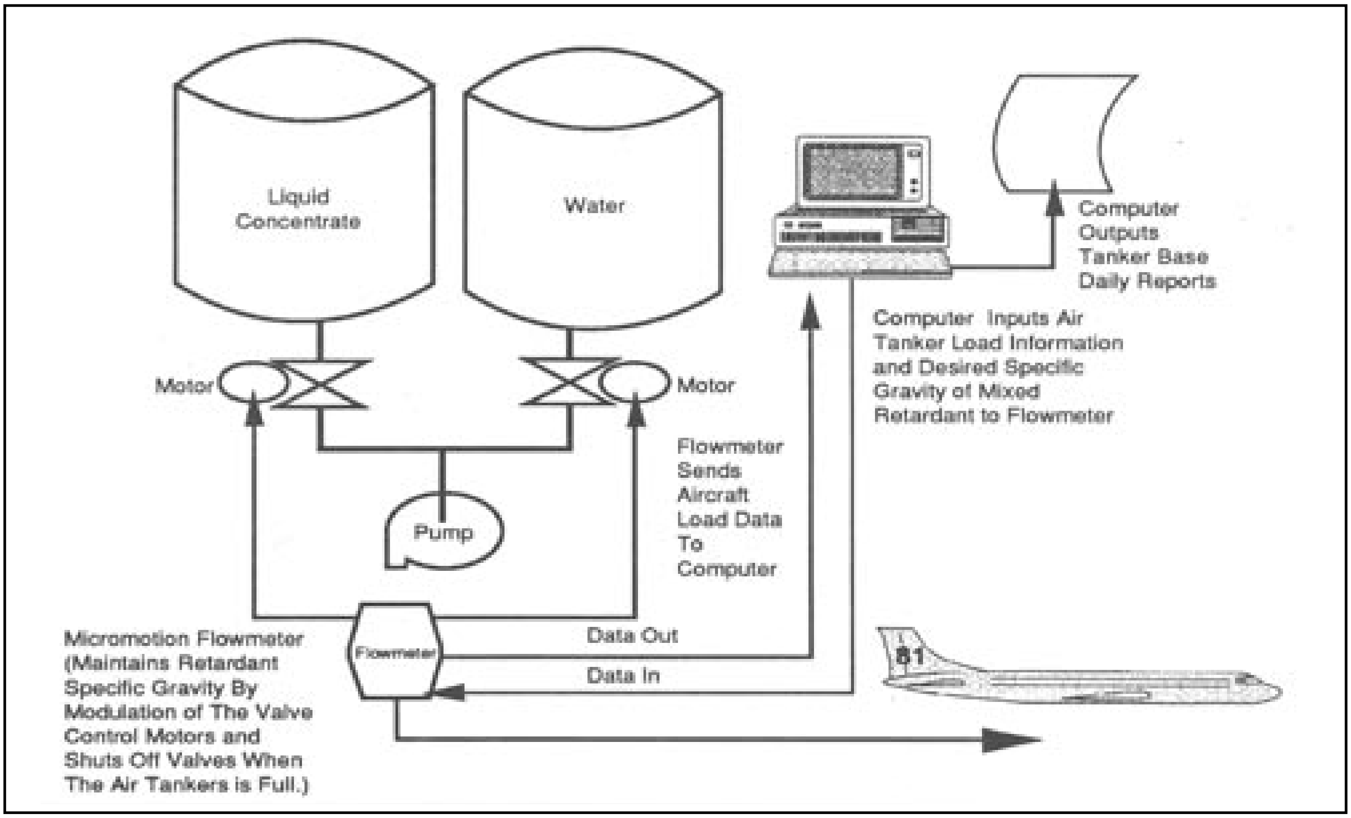

Figure D7—Micromotion meter blending system.

APPENDIX E
TANK RECIRCULATION AND MIXING

Tank recirculation and mixing was evaluated by discussion with airtanker base personnel, review of base systems, and utilization of available fluid mixing theory. To understand existing systems and to define the improved methods requires that the fundamental physics of mixing be first understood.

A brief explanation of these fundamentals is provided in this section. Using these fundamentals, along with reviewing the systems currently in use, it was concluded that most of the systems used at the present time can work well with a few minor modifications and a better basic understanding of how to correctly apply them.

Most noticeable was the lack of understanding of how to provide the maximum mixing energy available in the system to the mixing tank. The other issue was selection of the mixing device and its proper placement.

It appeared that the pumps currently in use, if properly applied, can provide the needed energy. The selection of the proper device is a more difficult decision. The physics of a submerged nozzle or diffusion device, such as a sparger tube, is extremely complex.

Since most of the systems looked at are reported to provide adequate mixing or recirculation, given enough time, the issue becomes one of defining which works best and how to properly apply these systems.

To accomplish this task requires field testing of existing facilities to determine standards for installation and the optimum location of the mixing device(s).

It is SDTDC's belief that a system, such as the Lee System (figure E1) can be slightly modified and standardized to provide good mixing in horizontal tanks.

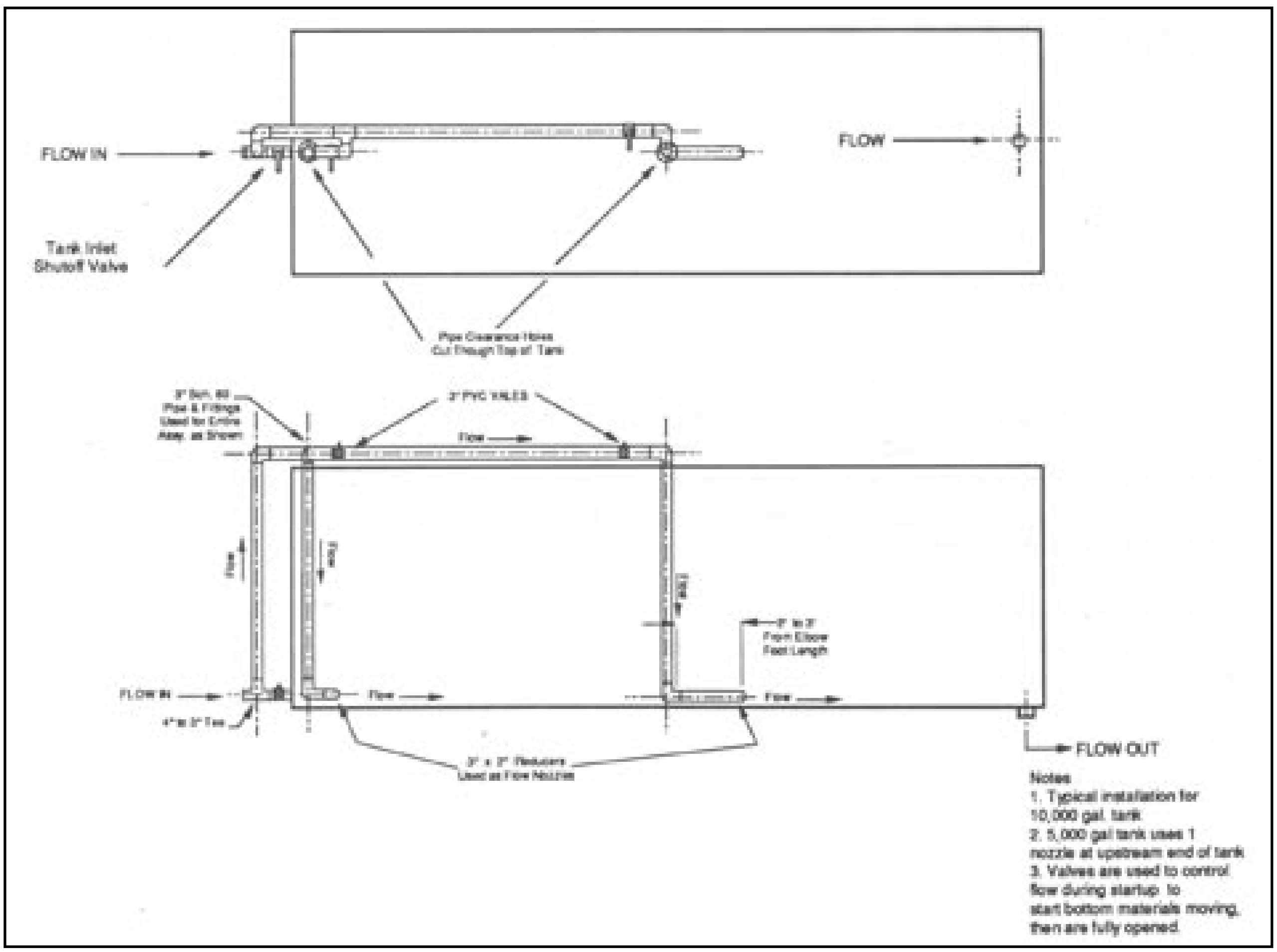

Figure E1—Lee circulation system.

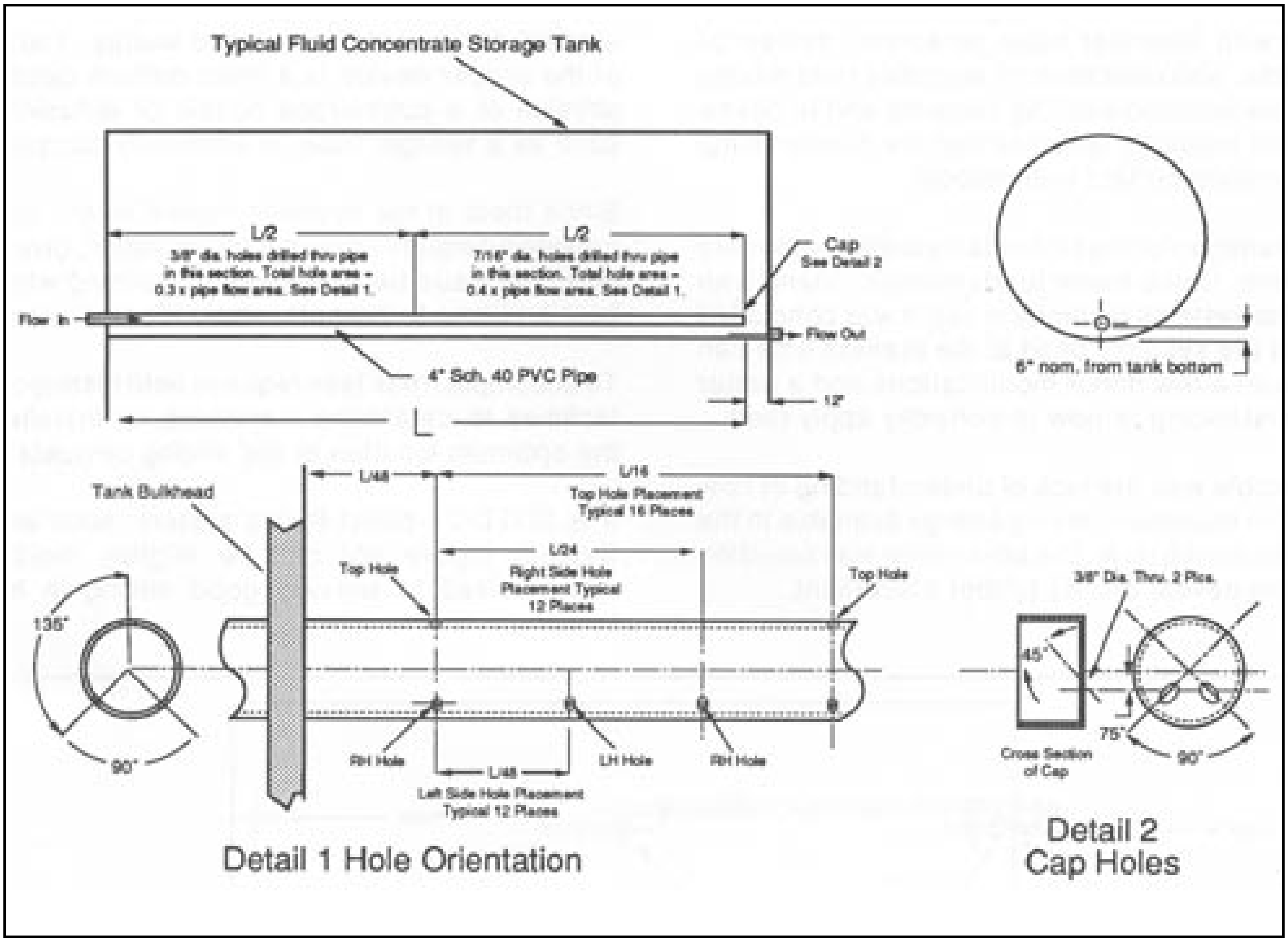

Figure E2—Sparger tube general arrangement and details.

The sparger tube (figure E2) was considered to be more complex than required. This device will work well if the hole sizing and arrangement is properly defined for the application. Without a detailed engineering study, this becomes, more or less, a trial and error procedure. Because of this process, further development of this device is not recommended.

An application of the methods given later in this section can give those who wish to continue using sparger tubes some insight into how to achieve successful results based on experience gained from existing systems. The Lee System modifications that are recommended for study are the use of eductor nozzles (figure E3) and throttling valves to improve pump performance. It is believed that optimization and standardization of this system will provide a design that is easy to apply and understand.

Vertical tank mixing is a more difficult problem than that observed in horizontal tanks. If the tank has a conical bottom (figure E4) the movement of settled solids is more readily facilitated.

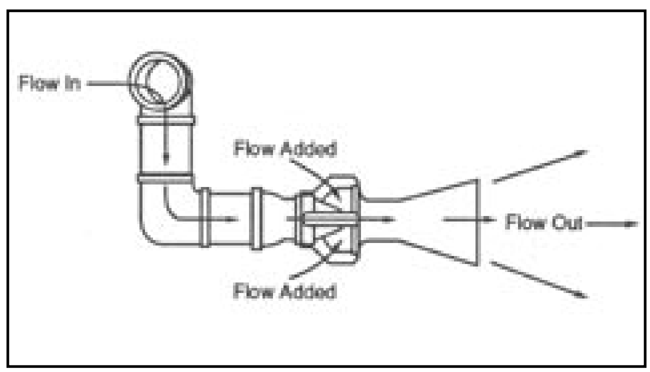

Figure E3—Eductor nozzle.

Most vertical tanks have flat bottoms because of the structural complexity of providing a conical bottom. The larger tanks (40,000 gallons upwards) looked at in California were reported to mix well using a system similar to that described in figure E5. SDTDC has not yet evaluated this method. Redmond Airtanker Base in Oregon has smaller tanks (10,000 gallon) that have experienced recirculation problems. A single eductor nozzle placed at the proper distance above the tank bottom may provide adequate recirculation for these smaller tanks.

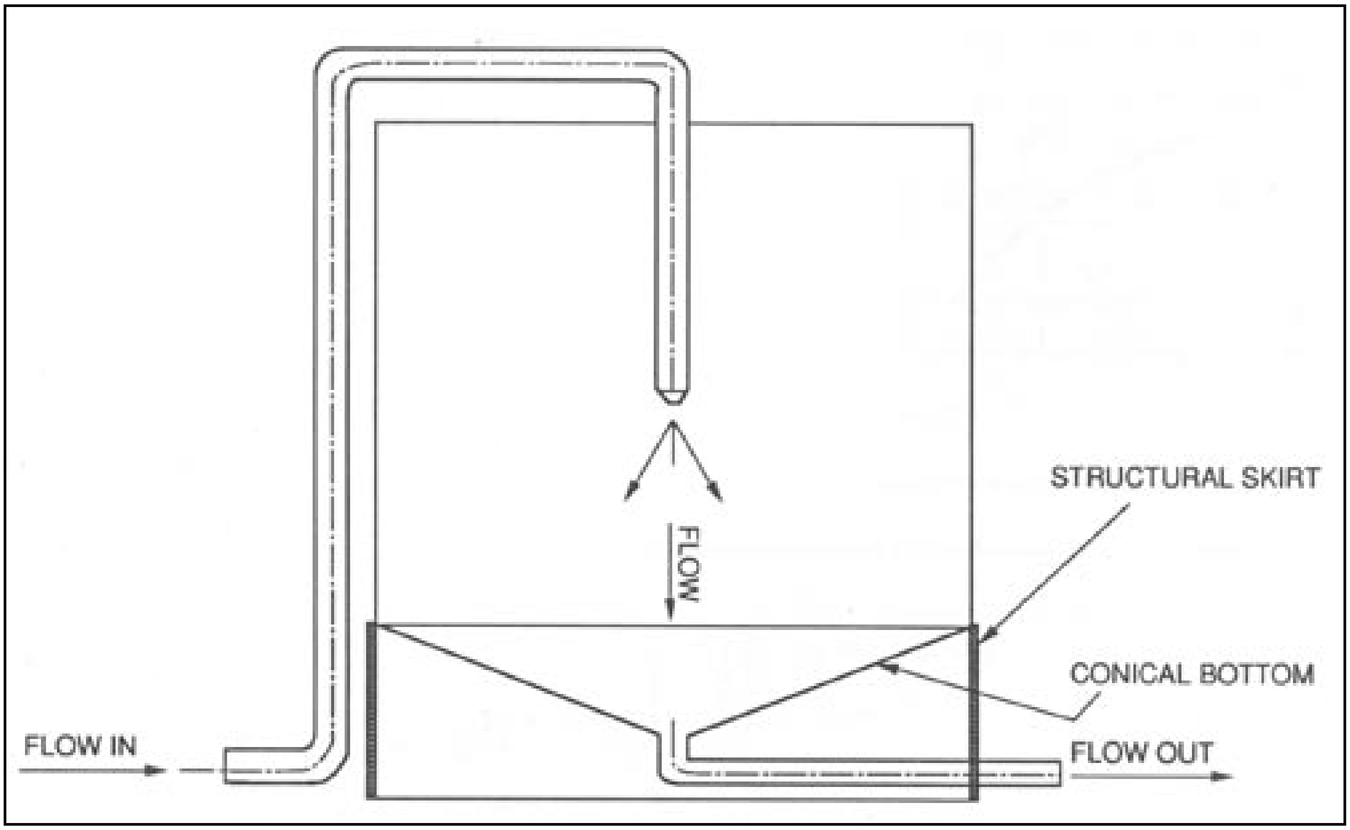

Figure E4—Vertical tank with a conical bottom.

Again, there is a need to get the maximum energy from the pump to properly define the application of either of these methods. To better understand vertical tank mixing and recirculation, it is recommended that field testing of both types of systems be conducted. Also, the use of eductor nozzles in the larger tanks should improve their circulation.

The key to success in any mixing arrangement, as mentioned previously, is to maximize pump performance. To accomplish this first requires that the manufacturer's performance curves for the pump planned for use be obtained. Using the curves, select the flow rate that is desired and determine the point the pump will yield its maximum efficiency at that flow rate.

Next, find the lift that corresponds to the maximum efficiency point on the curves. This value for lift is approximately equal to the back pressure the pump must have during mixing operations to provide the maximum amount of energy at the mixing flow rate.

To set this back pressure requires a pressure gauge immediately downstream of the pump outlet to measure the back pressure and a throttling valve near the same location to set the desired pressure. It is recommended that SDTDC conduct testing at an existing base. These tests will use pumps similar to those used at most bases to show the improvement in mixing and recirculation that can be obtained with this type of pump setup.

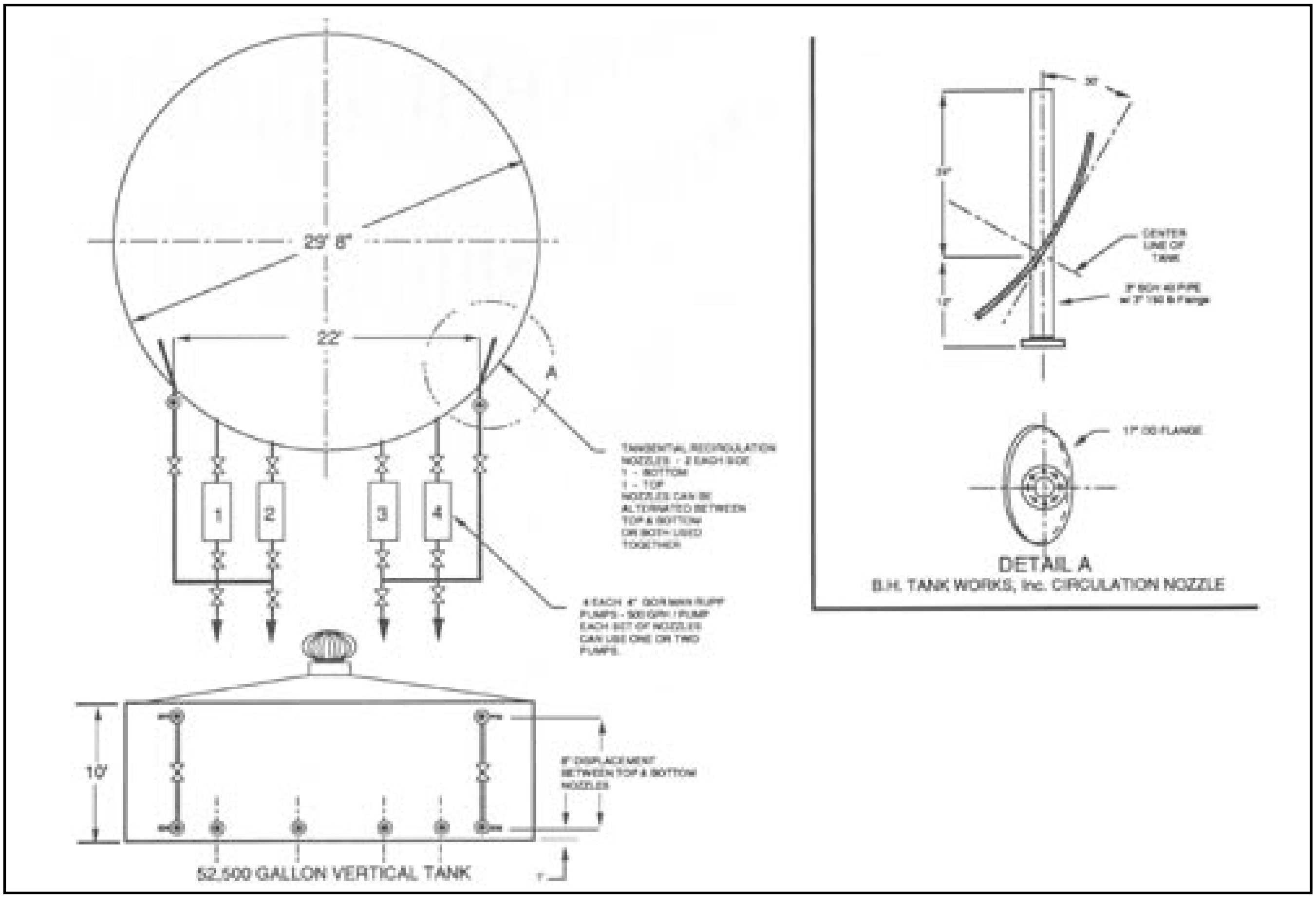

Figure E5—Large vertical tank recirculation system.

Fire Retardant Mixing and Recirculation Fundamentals
When setting up a new base or storage tank, how do you determine the equipment that is available will properly mix and/or recirculate the fire retardant product(s) the base will be required to use?

__Step 1__
Talk to base managers who have successfully mixed and recirculated the products you will be asked to accommodate. Find out the following about their equipment—ask questions:

Storage Tank Description

- Is it vertical or horizontal?
- What is the volume in gallons?
- Is the tank cylindrical or rectangular?
- You need the length or height and the diameter (in the rare case of a rectangular tank you need the length, width and height).
- Complete description of the active plumbing fixtures attached to the tank (get a detailed drawing if it is available).
- Does the tank have any special features such as a conical (for vertical tanks) or sloped bottom (for horizontal tanks), baffles, etc.? If so, you need dimensioned details.

Mixing and Recirculation Pump(s) Description

- What is the motor horsepower and rpm?

- What is the estimated flow rate during recirculation or mixing for each fire retardant?

- What is the make and model number?

- If possible, get a set of performance curves and data from the manufacturer.

Schematic of Mixing and Recirculation Piping
A complete system schematic that identifies the following is needed:

- Pipe ID and length between each fitting

- Location of each major component

- Each valve type and size. Include manufacturer and catalog number, if known

- The purpose of each valve during mixing and recirculation.

Description of Mixing or Recirculation Device
Propeller or turbine mixer for batch mixing, need:

- Horsepower

- Manufacturer and model number

- Mixing rpm

- Type of propeller used if there is a choice offered by the manufacturer.

Fluid mixer:

- Geometry - Need the most accurate description possible—detailed drawing is best.

- Location inside of tank for each component is required.

- Type? Sparger tube (figure E2) nozzle(s) (figure E3), other?

- Must have the total inlet and outlet flow areas!

Description of the Retardants Mixed or Recirculated Successfully

- Manufacturer

- Product name

- Average viscosities

  -Prior to mixing or recirculation at top and bottom of tank

  -After mixing or recirculation at top and bottom of tank

- Time required to achieve the desired viscosity throughout the tank in minutes.

- Are there any special problems with the product such as: A layer of scum on the surface, rapid separation after mixing, difficult to pump, etc.?

- Frequency of recirculation required, 5-minutes, every hour, once a da, once a week, etc.? This data is extremely important and needed to properly define the allocation of base system equipment and resources.

<u>Step 2</u>
Model the data collected during step one by use of the following:

Geometric Similarity
Ideally an exact duplication of a successful system will yield successful results. This will not always be possible to achieve. A geometrically similar system is the next best way. To accomplish this requires the following:

Tank
For best results, the closer the tank is to the same dimensions as that used in the successful system the better. However, tank active fluid volume and orientation are the most important. Systems that work well with a horizontal tank may not work well with a vertical tank.

Piping and Valves
The pipe size and type of control valves used should be the same as those used in the successful system.

Pump
Horsepower, maximum lift, and maximum flow rate must be known. Horsepower can be assumed equal to that of the motor. Maximum lift can be measured by placing a pressure gauge immediately downstream of the pump and shutting off the flow while the pump is running. The best way to get the pump data is to obtain the performance curves from the manufacturer.

Mixing Device Inside the Tank
Should be the same if the tank is the same. If the tank is not the same, the mixing device location and size should be proportionally scaled to the tank volume and length. That is, the location of each outlet should be spaced to achieve approximately the same relative location inside the tank as that observed in the successful system. If the pipe size used is the same, the net inlet flow area for mixing is the same.

The net outlet area should be the same as that used in the successful tank. Meaning, the sum of the mixing device outlets (orifices, holes, or nozzles) cross sectional area should equal the sum of those used in the successful tank. If a propeller mixer is used, make sure the propeller is the same as that used in the successful tank.

Step 3
Use the design and data obtained from steps 1 and 2 to define your new system in terms of the retardant(s) being considered for use.

To determine if the proposed installation will succeed, the criteria given in Step 2 to determine geometric similarity must be followed. Remember, the systems being compared must be similar. Do not compare a horizontal tank with a vertical tank or a propeller mixer with a fluid mixer, etc. Tank active volumes can differ, but their basic general shapes should be the same. The mixing device used should be the same as that used in the successful system. Dimensions may vary proportionally to the tank length and diameter.

Calculation of the Mixing Velocity Gradient
The velocity gradient is one way to estimate if your system will perform as well as the geometrically similar system on which you have based it. The procedure is as follows:

1. Follow the examples in this section and calcu late the velocity gradient for the similar system and your system for each retardant you are considering for use.
2. Use the velocity gradients to compare the mixing and recirculation time differences between the two systems.
3. Adjust your system design and repeat the calculations until satisfactory results are achieved.

Performing the calculations will give some insight into the suitability of a system for mixing and recirculation of a particular retardant or the effect on the system of changing products. It also indicates if adjustments in tank or pumping capacity may be necessary to efficiently handle a particular product.

Formulas and Conversion Factors

1. Pressure
Given pressure in psi
Need pressure in lbs/sq ft

p = pressure psi;

144 x p = pressure in lbs/sq ft

2. Specific Weight of a Fluid
Given specific weight in lbs/gal
Need specific weight in lbs/cu ft

w = specific weight lbs/gal;

7.48 x w = specific weight in lbs/cu ft

3. Mixing Tank Available Flow Energy

H = available energy in feet = (144 x p)/(7.48 x w)

or: H = 19.25 x p/w

4. Fire Retardant Viscosity
Given viscosity in centipoise (cps)
Need viscosity in (lb sec)/sq ft

u = viscosity in cps

$(2.089 \times 10^{-4}) \times u$ = viscosity in (lb sec)/sq ft

5. Tank Effective Mixing Volume

Given volume in gal

Need volume in cu ft

V = volume in gal; V/7.48 = volume in cu ft

6. Flow Horsepower

P = Flow Horsepower = (Q x p)/1714

Where:

Q = Mixing System Flow rate in gal/min

p = Tank Inlet Pressure in psi

Calculation of Velocity Gradient

$G = (w\ H)^{1/2}/(u\ T)^{1/2}$ equation 1

$G = (550\ P)^{1/2}/(V\ u)^{1/2}$ equation 2

Where:

G = Velocity Gradient in sec^{-1}

H = Tank Available Flow Energy in ft

u = Retardant Average Viscosity during mixing or recirculation in (lb sec)/sq ft

T = Time to achieve proper mixing or recirculation in sec

V = Tank Effective Mixing Volume in cu ft

P = Flow Horsepower

w = Retardant Specific Weight in lbs/cu ft

Using the given conversion factors, the equations for "G" can be rewritten as follows:

$G = [(68.9 \times 10^4)\ p)]^{1/2}/(u\ T)^{1/2}$ equation 1

$G = [(1.15 \times 10^4)\ Q\ p)]^{1/2}/(V\ u)^{1/2}$ equation 2

Where:

G = Velocity Gradient in sec

p = Tank Inlet Gauge Pressure in psi

Q = System Flow rate in gpm

V = Tank Effective Mixing Volume in gal

u = Retardant Average Viscosity during mixing or recirculation in centipoise

T = Mixing/Recirculation Time in sec

Example 1. **Fluid Mixers**

Given:

System Flow Rate, Q = 400 gpm

Tank Inlet Pipe Gauge Pressure, p = 50 psi

Tank Effective Mixing Volume, V = 10,000 gal

Retardant Viscosity, u = 1,000 centipoise

The measured System Mixing Time,

T_m = 1,800 sec

The measured System Recirculation Time

T_r = 300 sec

Find:

T_m and T_r for a similar system as follows:

Use equation 1 to calculate "G_m" and "G_r" from the above data for the **"Successful System."**

For G_m, $T = T_m$ = 1,800 sec

G_m = 4.37 sec^{-1} for mixing of the retardant used.

For G_r, $T = T_r$ = 300 sec,

G_r = 10.7 sec^{-1} for recirculation of the retardant used.

Equation 2 represents the energy per unit volume available to the mixing system and is independent of the time required to obtain a proper mix. However, it is dependent on retardant viscosity. Use equation 2 to calculate "G_s" for the **"Successful System."**

G_s = 4.8 sec^{-1} for the **"Successful System."**

To obtain a basis for comparing the **"Similar System"** to the **"Successful System"** it is assumed that:

$G_s\ T_{sm} = G_m\ T_m$ to define mixing time and,

$G_s\ T_{sr} = G_r\ T_r$ to define recirculation time.

Where: T_{sm} and T_{sr} are the system time constants for each case in seconds.

Then:

$$\mathbf{T_{sm} = (G_m\ T_m)/\ G_s = 1{,}642\ sec}$$

$$\mathbf{T_{sr} = (G_r\ T_r)/\ G_s = 670\ sec}$$

Compare the proposed similar system as follows:

Let: The tank volume = 7,000 gal

The retardant viscosity, u = 1,500 cps

All other variables equal their previous values.

Using equation 2, $\mathbf{G_s = 4.68\ sec^{-1}}$.

If $G_s\ T_s$ of the **"Similar System"** is set equal to that of the **"Successful System,"** T_s for the **"Similar System"** can be determined (**only works for geometrically similar systems**).

Or as before:

$G_s\ T_{sm} = G_m\ T_m$ to define mixing time and,

$G_s\ T_{sr} = G_r\ T_r$ to define recirculation time.

$G_s\ T_{sm}$ for "Successful System" = 7,875

$G_s\ T_{sr}$ for "Successful System" = 3,215

Then for the **"Similar System":**

$$\mathbf{T_{sm} = (G_s\ T_{sm})/\ G_s = 1{,}683\ sec}$$

$$\mathbf{T_{sm} = (G_s\ T_{sr})/\ G_s = 687\ sec}$$

Now it is assumed that $G_m\ T_m$ and $G_r\ T_r$ for the **"Successful System"** are equal to those of the **"Similar System."**

From equation 1 it can be shown that:

$$\mathbf{G_m = [(68.9 \times 10^4)\ p]\ /\ (G_s\ T_{sm}\ u) = 2.92\ sec^{-1}}$$

$$\mathbf{G_r = [(68.9 \times 10^4)\ p]\ /\ (G_s\ T_{sr}\ u) = 1{,}102\ sec^{-1}}$$

and,

$$\mathbf{T_m = (G_s\ T_{sm})\ /\ G_m = 2{,}700\ sec}$$

$$\mathbf{T_r = (G_s\ T_{sm})\ /\ G_r = 1{,}102\ sec}$$

Where the above values of T_m and T_r are the mixing and recirculation times respectively for the **"Similar System."**

Note: This sample calculation can be repeated by varying any of the system parameters to determine mixing time differences as long as the systems being compared are geometrically similar. If there are significant differences in pump and pipe size, or the ratio of pump horsepower to tank volume, this method may not work well. SDTDC will try to verify the useful range of this procedure in future testing.

This method does not consider fluid separation, stratification, physical differences, other than viscosity and other problems that may differ between fire retardants.

Example 2. Propeller Mixers (Turbine Mixers)
The method as demonstrated in the first example applies to fluid mixers only. For propeller or turbine mixers the method is as follows:

Use equation 2 in its initial form, or:

$G = (550\ P)^{1/2}/(V\ u)^{1/2}$ equation 2

Where:

G = Velocity Gradient in sec^{-1}

u = Retardant Average Viscosity during mixing or recirculation in (lb sec)/sq ft

V = Tank Effective Mixing Volume in cu ft

P = Mixer Motor Horsepower

Using the conversion factors given previously, equation 1 can be written as follows:

$G = ((1.97 \times 10^7)\ P)^{1/2}/(V\ u)^{1/2}$ equation 2

Where:

G = Velocity Gradient in sec^{-1}

u = Retardant Average Viscosity during mixing or recirculation in centipoise

V = Tank Effective Mixing Volume in gal

P = Mixer Motor Horsepower

For propeller mixers, the same propeller used for the **"Successful System"** must be used for the **"Similar System"** to maintain the similarity between the systems. Piping and tank geometry similarity are not as critical.

Given:

Mixer Horsepower, $P = 50$

Tank Effective Volume, $V = 10{,}000$ gal

Retardant Viscosity, $u = 5{,}000$ centipoise

Time Required to Mix, $T_m = 1{,}800$ seconds

Find:

Mixing time required for a similar system, where:

Mixer Horsepower, $P = 30$

Tank Effective Volume, $V = 7{,}000$ gallons

Retardant Viscosity, $u = 4{,}500$ centipoise

For the first system, $\mathbf{G_1 = 19.7\ sec^{-1}}$

For the similar system, $\mathbf{G_2 = 18.8\ sec^{-1}}$

Let G_1T_m = constant = $G_2T = 35{,}460$

so,

$\mathbf{T = (G_1T_m)/G_2 = 1{,}890\ sec,}$

Where T is the time required to mix in the similar mixer.