British Journal of Healthcare and Medical Research - Vol. 12, No. 02
Publication Date: April 25, 2025
DOI:10.14738/bjhr.1202.18415.
Young, A. L. (2025). Commercial and Tactical Herbicides used in Vietnam and Thailand During the Vietnam War. British Journal of Healthcare and Medical Research, Vol - 12(02). 62-75.

Commercial and Tactical Herbicides used in Vietnam and Thailand During the Vietnam War

Alvin Lee Young
A.L. Young Consulting, Inc., Cheyenne, Wyoming, United States

ABSTRACT

Issue: There continues to be much confusion among Vietnam and Vietnam-Era veterans, Non-Governmental Organizations, the Department of Defense, the Department of Veterans Affairs, and others as to the differences between the uses of military "tactical" herbicides versus the military use of "commercial" herbicides during the Vietnam War. If veterans were presumptively exposed to tactical herbicides while in military service in Vietnam, 9 January 1962 – 7 May 1975, they were entitled for health care for any of 19 different conditions "presumed to be service connected." Health care and compensation were provided by the Agent Orange Act of 1991. Approximately 50,000 United States Air Force Veterans served at Royal Thai Airbases in the Kingdom of Thailand during the Vietnam War, especially during the years 1965-1971. Thailand veterans were previously eligible for health care for any injuries they incurred during their service. However, they were not eligible for conditions under the Agent Orange Act. Nevertheless, there have been numerous allegations that US Thailand veterans were indeed exposed to the wide-spread use of the same tactical herbicides, e.g. Agents Orange, White, and Blue, that had routinely been used in Vietnam to control unwanted vegetation. In 2022, the US Congress passed the PACT Act that permitted veterans who served in Thailand and Guam during the Vietnam War to be eligible for health care and compensation for 26 different conditions "presumed to be service connected" to their exposure to Agent Orange and other tactical herbicides while in service in Thailand during the period 9 January 1962 to 30 June 1976. The Congress made the decision despite the absence of any evidence from available historical records or the absence of any knowledge about the use of "commercial herbicides" during the Vietnam War. Thus, the issue is whether Thailand veterans were exposed to tactical herbicides or commercial herbicides and has that exposure impacted their long-term health. Background: The first use of tactical herbicides was on 7 January 1962 in Operation RANCHHAND in South Vietnam. Approximately 74.2 million L of Agents Orange, White and Blue were sprayed on jungles, mangroves, savannas and for crop denial. Records confirmed that limited quantities of tactical herbicides were stored in Thailand for missions by RANCH HAND in Laos. When Thailand joined the Allied Forces in the Vietnam War in September 1964, the Thai government, under the Rules of Engagement, did not permit tactical herbicides to be used for vegetation control on Royal Thai Airbases. If not tactical herbicides, could commercial herbicides be the explanation for Thailand veteran allegations? Tactical herbicides differed from commercial herbicides in the development and testing of formulations, purchase specifications, guidelines, regulatory oversight, shipment requirements, toxicological evaluations and military record keeping. Findings: Recently identified procurement records confirm that at least 262, 800 L of commercial low volatile 2,4-D and 2,4,5-T herbicides were shipped and approved for vegetation control on four airbases in Vietnam, 1962-1971. Records confirm

that the total volume of low volatile 2,4,5-T shipped to Thailand was 29,120 L. Distribution to the Royal Thai Airbases and subsequent vegetation control was the responsibility of Pacific Architect & Engineers, a private company trained as commercial herbicide applicators for both Vietnam and Thailand. Dioxin (TCDD) analysis confirmed that the low volatile 2,4,5-T was ~ 1 ppm, and the rate of application, ~ 2.4 kg/ha, was similar to the same formulation sprayed in 1966 on 2.3 million ha on rangeland and pasture in the United States. It was also a choice herbicide for control of unwanted vegetation on most of the Department of Defense's more 500 bases worldwide. Policy Considerations: The Congress of the United States, the Department of Veterans Affairs, and the Thailand Veterans simply refused to accept the reality that little or no exposure to either tactical or commercial herbicides or TCDD ever occurred on Royal Thai Airbases in Thailand. The dilemma for the DVA is that to recognize Thailand veterans for commercial herbicide exposure fails to acknowledge that millions of military men and women were on hundreds of military bases worldwide that were sprayed with the same low volatile 2,4-D and 2,4,5-T commercial herbicides from 1962 -1972.

INTRODUCTION

There continues to be much confusion among Vietnam and Vietnam-Era veterans, Non-Governmental Organizations (NGOs), the Department of Defense (DOD), the Department of Veterans Affairs (DVA), and others as to the differences between the uses of military "tactical" herbicides versus the military use of "commercial" herbicides during the Vietnam War. There are numerous publications describing the use of tactical herbicides used during the Vietnam War [1, 2]. The use and quantities of commercial herbicides on military bases in Vietnam and Thailand have not been publicly documented. This article provides a background on the differences between tactical and commercial herbicides that were used in South Vietnam and Thailand during the Vietnam War and provides some quantifying data. The data presented poses interesting questions for the Department of Veterans Affairs as to their policy on exposure to herbicides and the associated contaminant by Vietnam-Era veterans.

Olson and Cihacek claimed in their 2023 article (*Use of Agent Purple, Agent Orange, and Agent Blue on Royal Thai Air Force Base Perimeters in Thailand during the Vietnam War*) that United States Air Force (USAF) personnel stationed at seven Royal Thai Airbases during the Vietnam War routinely used the tactical herbicides Agents Purple, Orange and Blue "to keep airbases and perimeter fences clear of vegetation." [3] Their article was intended to document and assess potential exposure of US Vietnam-Era Veterans serving in Thailand to arsenic (from Agent Blue) and the herbicide contaminant dioxin (TCDD, from Agents Purple and Orange) [3]. What is disturbing about their article published in the *Open Journal of Soil Science* is that they overwhelm the reader with extensive information that has no relevance to the topic. For example, they failed to provide scientific or historical facts for their conclusions in the above 28-page article, but rather the authors described "secret" CIA operations in Laos, Rules of Engagement, Rainbow herbicides, the disposal operations of Agent ORANGE on Johnston Island, Air Force standards for herbicide use in "unknown" manuals, and the extensive use of "Sworn Statements claiming exposure to the tactical herbicides by US Airman" (i.e., recall bias). [3] Lastly, Olson and Cihacek claimed that an "unlawful and arbitrary illusory distinction" exists with DVA's and DOD's use of the terms commercial and tactical herbicides [3]. Contrary to the Olson and Cihacek article, Young used the historical records archived within the National Archives and Records Administration (NARA), Suitland Park, Maryland, and the more than 400

URL: http://dx.doi.org/10.14738/bjhr.1202.18415.

pages of Air Force documents/reports on vegetation control in Thailand maintained by the Air Force Historical Research Agency (AFHRA), Maxwell Air Force Base. Montgomery, Alabama [4]. These records failed to support the allegation that veterans stationed in Thailand during the Vietnam War were ever exposed to Agent ORANGE or other tactical herbicides [4].

1991 AGENT ORANGE ACT AND ROLE OF THE INSTITUTE OF MEDICINE

In response to decades of health concerns by veterans who had returned from the war in Vietnam, the US Congress passed, and the President signed Public Law 102-4, the Agent Orange Act of 1991 [5]. In defining the herbicides for exposure presumption, the Agent Orange Act of 1991 stated "…the term 'herbicide agent' means a chemical in an herbicide "used in support of the United States and allied military operations" in the Republic of Vietnam during the Vietnam era." [5] Although the term "tactical herbicide" was not used in the Act, the intent was to restrict consideration to only those herbicides used in "military operations" and the associated dioxin contaminant. Thus, in defining its scope of scientific assessment in support of the Agent Orange Act of 1991, the Institute of Medicine (IOM) concluded that four herbicides had been documented in military records that had been involved in military operations [6]. Specifically, the herbicides were 2,4-D (2,4-dichlorophenoxy acetic acid, 2,4,5-T (2,4,5-trichlorophenoxy acetic acid), picloram (4-amino-3,5,6-trichloropicolinic acid) and cacodylic acid (hydroxyl-dimethyl arsine oxide) [6]. In addition, the IOM concluded that the contaminant TCDD (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) occurred in both commercial and military-procured 2,4,5-T herbicide [6]. Thus, it is important that a valid distinction be established between tactical herbicides and commercial herbicides used in Vietnam and Thailand.

THE USE OF TACTICAL HERBICIDES IN THE VIETNAM WAR

The first use of tactical herbicides was on 7 January 1962 in Operation RANCH HAND. The United States government terminated all use of tactical herbicides on 31 October1971. Remaining stocks of Agents White and Blue at Da Nang Air Base and Bien Hoa Air Base were subsequently sprayed by the South Vietnamese Air Force (VNAF) using aircraft given to VNAF by 7th Air Force as part of the Vietnamization Program. No records could be found as to the final fate of these stocks. However, the inventory was accounted for in the procurement records. [7]. Table 1 provides estimated quantities of tactical herbicides shipped and used in Vietnam. Historical records maintained by the Air Force Historical Research Agency indicated that no spraying of tactical herbicides by RANCH HAND aircraft occurred in Thailand. However, the records confirmed that there were RANCH HAND operations based at Udorn RTAFB for missions over Laos. From October 1969 through September 1969, RANCH HAND aircraft sprayed ~55,000 L of Agent Blue, and ~60,000 L of Agent Orange on 3,642 ha of crops and forestry areas in Region V, Laos. The tactical herbicides were temporarily stored at Udorn in anticipation of the missions [7].

Table 1: Estimated quantities of Tactical Herbicides used in Vietnam, 1961-1972 [7]

Tactical herbicide	Commercial components	Number of drums[1]	Number of liters	Years of use
Green[2]	2,4,5-T	365[3]	75,920	1962
Pink[2]	2,4,5-T	1,315	273,520	1961—1963
Purple[2]	2,4-D; 2,4,5-T	12,475	2,594,800	1962—1965
Blue	Cacodylic Acid	29,330	6,100,640	1966—1972
White	2,4-D; Picloram	104,800	21,798,400	1966—1972

Orange[2]	2,4-D; 2,4,5-T	208,330	43,332,640	1965—1970
Total		356,615	74,175,920	

[1] Data based on the US Defense Supply Agency and Air Force Logistics Command records. [2]These tactical herbicides contained 2,4,5-T and its association contaminant, TCDD. Pink was used in the 1964 Thailand tests, but available data indicated last use of Pink in South Vietnam was in 1963; the Daily Air Activity Reports often confused Purple and Pink [7]. [3]All herbicide drums sent to Vietnam were of 18-guage steel and held 208 L of product that were applied in concentrated form and not diluted.

TACTICAL VERSUS COMMERCIAL HERBICIDES

Tactical herbicides differed from commercial herbicides in the development and testing of formulations, purchase specifications, guidelines, regulatory oversight, shipment requirements, toxicological evaluations, and military record keeping [8].

Developing and Testing of Formulations – Tactical Herbicides

Because of the myriad vegetative types present in the various combat environments of South Vietnam, the desired characteristics of an effective defoliant were the following: broad spectrum of activity on many kinds of plants; rapid in action so that the results of defoliation or leaf drop could be observed within a three-day period; suitable for application with air or ground equipment; essentially nontoxic to man and animals at the approved application rate; stable in storage to insure effectiveness following global transportation and temporary storage; effective in low dosages from aerial or ground applications; readily available in larger quantities from commercial manufacturers; and, the formulation must be noncorrosive. From 1953 through 1967, the scientists at Fort Detrick conducted field evaluations of potential tactical herbicides at more than 30 locations and covering a wide range of vegetation. Four compounds were selected to be formulated as tactical herbicides 2,4-D, 2,4,5-T picloram, and cacodylic acid. These four compounds met the desired characteristics of an effective defoliant [8]. The most effective formulations for 2,4-D and 2,4,5-T, either singly or as mixtures, were primarily the highly volatile water insoluble n-butyl or iso-butyl esters. These highly volatile esters were formulated as a concentrated product containing ~1.04 kg of active ingredient (ai) per L [8, 9]. They did not include diluents (to dilute the ai), adjuvants (to enhance effectiveness) or surfactants (to improve spreading on the leaves). Thus, the tactical herbicides Agents Green, Pink, Purple and Orange contained these concentrated esters that were not diluted before spraying. The most effective formulation of picloram was a 1:4 mixture with 2,4-D formulated as the water soluble triisopropanolamine salts. This concentrated formulation contained 65 g ai picloram and 240 g ai 2,4-D per liter, and became the tactical herbicide, Agent White [9, 10]. It was not diluted before spraying. The most effective formulation of the organic arsenicals evaluated by Fort Detrick scientists was a concentrated formulation of the water-soluble sodium salt of cacodylic acid. The tactical herbicide Agent Blue contained 370 g ai per L cacodylic acid/sodium cacodylate. It was not diluted before spraying [10, 11]. RANCH HAND aircraft sprayed the tactical herbicides at the rate 28 L/ha [11]. For Agent Blue this amounted to 3.5 kg ai/ha [11].

Developing and Testing of Formulations – Commercial Herbicides

Under the Directives 5154.12 and 4150.7, the Department of Defense established pest management policy but gave the Armed Forces Pest Control Board (AFPCB), now the Armed Forces Pest Management Board (AFPMB), the responsibility to implement and provide oversight for that pest management policy that was "*applicable for all Department of Defense*

URL: http://dx.doi.org/10.14738/bjhr.1202.18415.

pest management activities in any unit, at any time, in any place, even when conducted by contract operations." However, the responsibility for tactical herbicides was specifically not assigned to the AFPCB. The AFPCB was established in 1955. During the Vietnam Era, the Armed Forces Pest Control Board provided the oversight for the selection of USDA-approved commercial herbicides used on all military installations [8]. The Board did not work with the chemical companies manufacturing pesticides, rather, these materials were evaluated through a Memorandum of Understanding (MOU) with the United States Department of Agriculture (USDA). USDA recommended the formulations based on research conducted by the Agricultural Research Service and validated by the Cooperative State Research, Education, and Extension Service, and the United States Extension Service. These studies focused on individual weed or brush species, by location, and by use of either ground or aerial application systems. USDA-approved formulations of 2,4-D and 2,4,5-T were widely used in commercial, private and governmental agronomic, horticultural, forestry and rangeland programs. These formulations included low volatile esters, inorganic salts, and amine salts. These formulations included diluents (to dilute the active ingredient), adjuvants (to enhance effectiveness) and surfactants (to improve the spreading on the leaves). By the time of the Vietnam War, *the n-butyl esters and isobutyl esters were not used commercially because of their volatility***.** There were (and continue to be) many approved commercial formulations of the herbicide picloram (Tordon®), including formulations with 2,4-D. However, during the Vietnam War, the White formulation (Tordon 101®) was not available as a commercial product for DOD installations; and there were (and continue to be) many commercial organic arsenical herbicides. However, during the Vietnam War, the Blue formulation (Phytar 560G®) was not available as a commercial product for DOD installations [9, 11].

Purchase Specifications – Tactical Herbicides

The actual formulation specifications for the tactical herbicides were prepared by the Army Chemical Corps and those specifications were provided to the Defense Supply Agency (DSA) for procurement actions. The acquisition of tactical herbicides was initially the responsibility of the US Army Chemical Corps but in 1962 this responsibility was transferred to the Middletown Air Materiel Area, Olmsted Air Force Base (AFB), Pennsylvania, and in August 1966 this responsibility was assigned to the Air Force Aerospace Fuels at the San Antonio Air Materiel Area, Kelly AFB Texas. Using "Military Specifications", the procurement of all tactical herbicides was done by the DSA [9]. Military Specifications were complete documents and were used when the need for the materials was confined to a specific military operation (e.g., all of the tactical herbicides used in tactical operations in Vietnam) [9].

Purchase Specifications – Commercial Herbicides

The AFPCB adopted the policy for the Department of Defense to recommend that any pesticide formulation that has uses in civilian agencies be issued as a "Federal Specification" These types of pesticide were to be issued by the Military Supply System (during the 1960s) within the General Services Administration. By 1966, the AFPCB strictly controlled the kinds and forms of pesticides available under "Federal Specifications" and on the military supply list. New pesticides, before being considered by the Board, had to be recommended by the USDA, the US Fish and Wildlife Service, or the Public Health Service, and the proposed use had to have been approved by all three of these organizations [8].

Use Guidelines – Tactical Herbicides

Simultaneously with the development of the tactical herbicide formulations, the US Army Chemical Corps' Plant Sciences Laboratories at Fort Detrick worked closely with the United States Air Force's Air Development Test Center and the Air Force Armament Laboratory at Eglin AFB Florida to develop and test the aerial spray equipment using the actual tactical herbicide formulations so that compatible spray systems would be deployed for use in Vietnam [8]. The development of the aerial spray equipment was a challenge that required interfacing the necessary dissemination characteristics with the biologically effective rate of application, i.e., "the minimum biologically effective ground deposition level of herbicide". The extensive field tests by the Fort Detrick scientists indicated that an aerial application rate of 28 L/ha of concentrated herbicide would provide an effective control over most of the flora found in South Vietnam. Generally, RANCH HAND missions achieved optimum defoliation by flying at 130-149 knots at an altitude of 35-50 m above ground level. The UC-123B/K/AA 45Y-1 Spray System was designed to produce a median spray droplet size of 320-350 μm. A full tank of herbicide contained 3600 L (with 200 L remaining in the spray system) and was sprayed in approximately 3.5 – 4 min over a spray swath 80 m wide (± 6 m) and 14 km in length, for total are coverage of 130 ha [8]. Approximately 95% of the tactical herbicides were aerially applied by RANCH HAND UC-123B/K aircraft; the remaining 5% applied by US Army Chemical Corps helicopters, e.g., the Army UH-1, and ground equipment, including the Buffalo Turbine [9, 10].

Use Guidelines – Commercial Herbicides

As previously noted, the selection of commercial herbicides including their use recommendations and appropriate application equipment was through a MOU with USDA. The guidelines for the use and application rate of specific herbicides within USDA designated requirements, and the selection of USDA-approved application equipment were adopted by the AFPCB and by the various branches of the military. For example, in 1970 the Herbicide Manual for Noncropland Weeds was published as an Army, Navy and Air Force Manual [12]. The herbicides 2,4-D and 2,4,5-T were two of the most widely used herbicides in the world from 1960 through 1978. The herbicide formulation Tordon 101® was frequently used for vegetation management on rights-of-way. The herbicide formulation Phytar 560 was frequently used for selective control of grass species, some woody vegetation, and in cotton defoliation [12].

Regulatory Requirements – Tactical Herbicides

Neither the AFPCB nor the USDA had regulatory authority or oversight of the selection or use of herbicide formulations developed by the Department of the Army for tactical military operations. Thus, tactical herbicides were not required to be labeled, nor required to comply with the directions from the Pesticide Regulation Branch of USDA or with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). The only labeling requirements for tactical herbicides were a 15-cm colored band around the center of the 208-L drums to identify the specific tactical herbicide, e.g., Orange, Blue, or White, and the lids were stenciled with a brief description of the herbicide formulation (e.g., "HERBICIDE BUTYL ESTERS, 50% 2,4-D and 50% 2,4,5-T), the Federal Specification Number (FSN), Transportation Control Number, US Port of Embarkation (e.g., Transportation Officer, Gulf Outport, Mobile, Alabama), destination (e.g., ARVN 511th Ordinance Storage Depot, Da Nang, Vietnam), DSA Procurement Number and date, and net weight of contents [8, 9]. The overall policy and procedures for herbicide operations in Vietnam were set forth in detailed directives issued by the Military Assistance Command,

URL: http://dx.doi.org/10.14738/bjhr.1202.18415.

Vietnam (MACV); and, These directives were based upon specific guidelines provided by the Department of State and the Army Chemical Corps. The most important of these directives was MACV Directive 525-1 which governed all tactical herbicide used by both US and Free World Military Assistance Forces troops between 1965 and 1970. This Directive prescribed policies, responsibilities, and procedures governing the operational employment of tactical herbicides within South Vietnam, including all fixed wing, helicopter, and surface-based methods of herbicide application [8].

Regulatory Requirements – Commercial Herbicides

It was and it remains DOD policy that all commercial pesticides used by DOD, including herbicides, were to be applied only by certified applicators or under the direct supervision of a certified applicator. Although each military service managed its own pesticide certification program, the coordination and oversight of these programs with other agencies occurred at the level of the AFPCB. Department of Defense Directive 4150.7 established the regulations and standards for pest control operations for DOD Installations, compatible with national objectives for the protection of the environment. Within this Directive, certification was defined as the attainment of competency for pest control operators and supervisors equal to standards recommended by the AFPCB. Certified personnel used only USDA-approved equipment and pesticides. The AFPCB, operating under the Office of the Secretary of Defense, had the major responsibility to coordinate the applicator certification plan among the operating agencies. The application of an approved commercial herbicide could only be done inside the base perimeter of a military installation and by a Board "certified" (trained) applicator with equipment that had been approved by the USDA, and/or under the supervision of the Base Civil Engineer. Commercial herbicides used on Allied Bases in Vietnam around buildings, in equipment storage sites, and along interior roads inside the base perimeters were those recommended by the AFPCB [8]. The responsibility for the purchase and application of commercial pesticides on these installations was the Base Civil Engineer (Facilities Engineer), not the Army Chemical Corps.

Shipment Requirements – Tactical Herbicides

Tactical herbicides were shipped in 208-L drums by rail from the manufacturer to the Port of Embarkation. Approximately 128 drums were loaded per boxcar. At the railroad terminal the drums were loaded on pallets and taken to the pier by forklifts. The transport of tactical herbicides required concurrence by the US Army Chemical Corps and/or the Middletown Air Materiel Area or the San Antonio Air Material Area with full approval of the Military Sea Transportation Service. Shipments were authorized by a DD Form 173 "Joint Message Form" [8]. This was critical so that schedules were established and stevedores and barges or derricks were dispatched to the dock and ship to facilitate the loading and unloading of the drums, and arrangements made to ensure the safety, transport, and storage of the defoliants. When the drums of tactical herbicides arrived in Vietnam, the ownership was transferred from the USAF to the Army of the Republic of Vietnam (ARVN). The ARVN had the responsibility for the handling, transport, and storage of the tactical herbicides at each of the RANCH HAND unit locations. Most of the personnel involved in the actual handling of the drums of herbicides were ARVN troops assigned to support the RANCH HAND and US Army Chemical Corps Operations [8, 9].

Shipment Requirement – Commercial Herbicides

Once a USDA-approved commercial herbicide met AFPCB operational requirements, it was assigned a Federal Standard Stock number (FSN) and would be listed in the Federal Stock Catalog as available from the General Services Administration. The responsibility for the purchase and acquisition of USDA-approved commercial herbicides on military installations was the Base or Facilities Civil Engineer, often with the advice of a Base Agronomist or even the Command Entomologist or Command Surgeon. However, all commercial herbicides used within a military base required AFPCB-approved trained contractors to conduct spray operations, or under the supervision of personnel trained in their use [8].

Toxicological and Safety Evaluations – Tactical Herbicides

Initially the toxicological and safety evaluations of 2,4-D and 2,4,5-T formulations were conducted by the US Army Chemical Corps and the US Army Environmental Hygiene Agency. However, with the extensive use of these compounds in agriculture, toxicological and safety evaluations of most herbicides including picloram and cacodylic acid were generally conducted by the chemical companies that manufactured the herbicides, and by governmental laboratories or contractual laboratories. Beginning in 1970 the first data were available on the contaminant 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) found in the 2,4,5-T that was used both commercially and in the tactical herbicides. Today, hundreds of studies are available on the dioxin contaminant TCDD [1].

Record Keeping – Tactical Herbicides

The scientists at Fort Detrick had the responsibility of preparing and publishing technical reports on the laboratory, plot tests, and field tests conducted on candidate herbicides. In addition, these scientists prepared trip reports from their visits of operations in Vietnam. Many of these reports were initially classified or restricted for public dissemination, but most are now publicly available within the National Archives or other document repositories [8]. The Air Force Logistics Command maintained the records on procurement and shipment of the tactical herbicides and these records are now maintained in the National Archives, especially the Air Force Historical Research Agency. Record keeping by the United States military in Vietnam was complicated by both the interface with the South Vietnamese allies in joint or mixed operations and by the precipitous manner that terminated the war and resulted in the rapid pullout of Allied Forces. Nevertheless, the US Army Chemical Corps took seriously the responsibility for maintaining the large majority of records on the use of tactical herbicides in Vietnam. The use of tactical herbicides by RANCH HAND (7th Air Force) and the US Army Chemical Corps were recorded on the HERBICIDE REPORTING SYSTEM (HERBS Tape) and assembled by the National Research Council of the National Academies of Sciences. The HERBs Tape has been made available to the public [6, 13].

Record Keeping – Commercial Herbicides/Pesticides

To ensure that military installations were identifying and controlling pests detrimental to military personnel, property, projects, and programs, the AFPCB had a cadre of military and civilian personnel via supporting Agencies and Laboratories (e.g., the Epidemiology Division of the School of Aerospace Medicine, Brooks AFB, Texas; USAF Occupational and Environmental Health Laboratory, Kelly AFB, Texas; and the Public Health Service) who routinely conducted Pest Surveys, Staff Visits, Training Programs, and Conferences on identifying and controlling pests, including vegetation. Reports of these visits, programs, and conferences were published

URL: http://dx.doi.org/10.14738/bjhr.1202.18415.

by the AFPCB and widely circulated to other military installations. Normally Base or Maintenance Facilities Organizations maintained use and procurement records of herbicides and other pesticides for only five years [8].

THE USE OF COMMERCIAL HERBICIDES IN THE VIETNAM WAR

In 1979, Roger Fox, a military historian who served in Vietnam, published for the Office of Air Force History "*Air Base Defense in the Republic of Vietnam, 1961-1973*" [14]. Fox noted:

> *Good fields of fire and fields observation were essential to clear perimeters. Herbicide needs of primary bases were specific, permanent, and known in advance. Still no ongoing long-term program to satisfy them was ever set up. Instead, the job was done piecemeal with each base handling herbicide requests. Despite the administrative and technical controls, herbicides remained the single sure way to control vegetation in placed where other means could not…notably in the critical perimeter complexes [14].*

In South Vietnam, the vegetation on the base perimeters were controlled by the use of tactical herbicides, especially with the use of Agent Blue. Tactical herbicides could NOT be used within the base perimeters, and only the US Army Chemical Corps were authorized to spray tactical herbicides on the perimeters [8, 9, 10]. For large military airbases the US and Allied Forces had agronomist and pest control units assigned to the Base Engineers. If herbicides were required by the Base Engineer, they were required to be commercially approved by the AFPCB [12]. The AFPCB routinely provided TDY (Temporary Duty) specialists to assist these bases first through assessing the vegetation control needs and then recommending appropriate commercial herbicides [8].

For Thailand, the uses of tactical herbicides were not authorized under the Rules of Engagement (ROE) with the Thailand Government, nor were they available for procurement by Base Engineers stationed at any of the six joint Royal Thai Air Force Bases (RTAFB) (Korat, Nakhon Phanom, Takhli, Ubon, Udorn, and U-Tapao) [15]. Procurement data on commercial herbicides were available from the Federal Supply Catalogs as identified in the Army and Navy Supply Bulletins [16]. The Supply Bulletins provided the available herbicides with descriptive information to include specifications and both Federal Stock Numbers and Federal Supply Catalog Identification Index Numbers. The Supply Bulletins also provided unit package size, e.g. pails, drums, bags, and price per unit package [16]. Contracts for the commercial herbicides were administered by the Defense Contract Administration Services with a DSA contract number assigned [16] The company awarded for the production of the herbicide interfaced with base purchaser for date, time, and route of shipment [16].

There were three major commercial herbicides used in both South Vietnam and Thailand [6]:
Herbicide 2,4,5-Trichlorophenoxy acetic acid in accordance with Federal Specification O-H-210 dated 5 Sept 58, and amended 8 Aug 61, Type II, class 2, liquid low volatile ester (stock number 6840-577-4201). Available in pails and drums, metal (19 L and 208 L), and appropriately marked for shipment [16]. Formulation contained 0.48 kg ai 2,4,5-T/L.

Herbicide 2,4-Dichlorophenoxy acetic acid in accordance with Federal Specification O-H-200 dated 6 Aug 1956, and amended 18 Sept 68, Type II, class 2, liquid amine salt (stock number

6840-664-7060. Available in pails and drums, metal (19 L and 208 L), and appropriately mark for shipment [16]. Formulation contained 0.48 kg ai 2,4-D/L.

Herbicide 2,4-Dichlorophenoxy acetic acid in accordance with Federal Specification O-H-200a dated 6 Aug 1956, and amended 18 Sept 68, Type 3, class 2, liquid low volatile ester (stock number 6840-577-4195). Available in pails and drums, metal (19 L and 208 L, and appropriately marked for shipment [16]. Formulation contained 0.48 kg ai 2,4-D/L.

For Thailand, another herbicide that was frequently purchased for perimeter use was TELVAR® (Monuron, stock number 6840-514-0644) a nonselective commercial soil sterilant available in a granular form and shipped in fiber drums containing 350 kg product [15, 16].

Beginning in May 1965, MACV's (Military Assistance Command, Vietnam) Directorate of Construction established a contract with Pacific Architects and Engineers (PA&E), that among many of their tasks was the use of professionally trained personnel approved by the AFPCB to spray commercial herbicides on military bases in South Vietnam and Thailand [17]. When commercial herbicides were received in South Vietnam, they were directed to the specialists with PA&E. This civilian organization had personnel stationed at many bases in both South Vietnam and Thailand to receive the herbicides and coordinate with the Base or Facilities Civil Engineer for the spraying of the herbicide [8, 17].

COMMERCIAL HERBICIDES SUPPLIED TO VIETNAM & THAILAND

In May 1963, the United States Army Chemical Procurement District, New York invited bids on the production and delivery of Herbicide 2,4,5-T (stock no. 6840-582-5440 (now 6840-664-4201), and Herbicide 2,4-D (stock nos. 6840-577-4194 and 6840-664-7060). Riverdale Chemical Company, Chicago Heights, Illinois won the bids [18]. Riverdale provided commercial herbicides to the DSA from 1963 – 1972. Registrations of the herbicides were with the Pesticide Division, Agricultural Research Service through 1970, at which time registration was with the United States Environmental Protection Agency [18]. Responsibility for transport to Vietnam and Thailand was with the Defense Logistics Agency [19]. On 1 January 1963, the Agency acquired Army general depots at Columbus, Ohio and Tracy, California, and the Navy Depot at Mechanicsburg, Pennsylvania. Acquisition of Army depots at Memphis, Tennessee, and Ogdon, Utah on 1 January 1964, completed the DSA depot network [19]. Commercial Herbicides received at these depots were then shipped to "Military Ocean Terminals" where a US Merchant Marine vessel transported them to either Saigon or to the US Army Sattahip Complex, Thailand [20]. At both locations the herbicides were provided to PA&S locations where they were maintained until requested by the base Civil or Facilities Engineer. When shipped by air, they would often be stored at the US Army Supply Service Depot at Machinto, Okinawa, until requested in South Vietnam [18]. When shipped as "SEA Express", they were shipped from an outport on the West Coast directly to Saigon or other locations in Vietnam.

Description of Commercial Herbicides Supplied to Vietnam

Riverdale Chemical Company was a small privately-owned chemical company established in 1957 as a specialist in processing and formulating 2,4-D and 2,4,5-T weed and brush control chemicals. The Company would purchase the dry acid form of 2,4-D and 2,4,5-T generally from the Dow Chemical Company, Diamond Shamrock Chemical Company, or the Chipman Division of Rhodia Inc. [18]. The 2,4-D acid was formulated into either a low volatile ester or an amine

URL: http://dx.doi.org/10.14738/bjhr.1202.18415.

salt. The 2,4,5-T acid was formulated into a low volatile ester. Once formulated, the product was ready for sale.

Quantities of Commercial Herbicides Shipped to Vietnam

- December 1962. 880 pails (19 L) 2,4-D amine salt were shipped to the Navy Depot at Mechanicsburg to the Military Ocean Terminal at Bayonne, New Jersey for shipment to Saigon, Vietnam.
- December 1963, 1,216 pails (19 L) low volatile 2,4-D were shipped to the Navy Depot at Mechanicsburg to the Military Ocean Terminal at Bayonne, New Jersey for shipment to Saigon.
- September 1964, 1,100 pails (19 L) low volatile 2,4-D were shipped to Army Depot at Tracy, California, and to the Military Ocean Terminal at Bay Area, Oakland, for shipment to Saigon.
- November 1964, 950 pails (19 L) low volatile 2,4,5-T were shipped to Army Depot at Tracy, California, and to the Military Ocean Terminal at Bay Area, Oakland, for shipment to Saigon.
- September 1965, 733 pails (19 L) low volatile 2,4,5-T and 35 pails (19 L) of 2,4-D low volatile were shipped to the Atlanta Army Depot, George and to the Savannah Outport for Shipment to Saigon.
- February -August 1966, 1,536 pails (19 L) low volatile 2,4,5-T were shipped to Army Depot at Tracy, California, and to the Military Ocean Terminal at Bay Area, Oakland, to the US Army Supply Service and Machinato, Okinawa.
- March -June 1967, 1,570 pails (19 L) low volatile 2,4,5-T and 40 pails (19 L) of low volatile 2,4-D were shipped to Seatle, Washington and to the Portland Pacific Northwest MTMTS Terminal via SEA Express to PA&S for distribution to Bien Hoa, Long Binh, and Qui Nhon, Vietnam.

In December 1967, the Department of Defense restricted the total national production of butyl esters of 2,4,5-T so it would be available for the Southeast Asia Defoliation Program. Thus, Riverdale Chemical Company could not purchase 2,4,5-T acid for formulation of the low volatile esters until late 1968 [18].

- March 1968, 770 pails (19 L) low volatile 2,4-D were shipped to Army Depot at Tracy, California, and to the Military Ocean Terminal at Bay Area, Oakland, for shipment to Saigon.
- October -November 1968, 504 pails (19 L) low volatile 2,4,5-T were airlifted to PA&S at Bien Hoa, Vietnam, for delivery NLT 30 December 1968.
- November 1969, 770 pails (19 L) low volatile 2,4,5-T were shipped to Army Depot at Tracy, California, and to the Military Ocean Terminal at Bay Area, Oakland, for shipment to Saigon.
- June 1971, 1,100 pails (19 L) low volatile 2,4-D were shipped to Army Depot at Tracy, California, and to the Military Ocean Terminal at Bay Area, Oakland, for shipment to Saigon.
- The United State Army Corps of Engineers purchased 240 drums (208 L) of 2,4-D amine salts between July 1967 and June 1971. This herbicide was used for controlling water weeds near piers and for civic action. It was shipped out of the Gulf Outport, New Orleans, Louisiana to Vietnam.

Quantities of Herbicides Shipped to Thailand

- Between August 1969 and October 1969, 140 drums (208 L) of low volatile 2,4,5-T were shipped to Seattle, Washington and to the Portland Pacific Northwest MTMTS Terminal via SEA Express to the Thai Sattahip Naval Base and off loaded to Pacific Architect & Engineers facilities at the US Army Depot Sattahip Complex, Sattahip, Thailand [18]. The Naval Base is located on the Southern tip of Thailand and Southeast of Bangkok.

DISCUSSIONS AND CONCLUSIONS

The total volume of 2,4-D amine shipped by Riverdale to Vietnam from 1962-1971 was 66,640 L, while the volume of 2,4-D low volatile ester was 80,960 L. The total volume of 2,4,5-T low volatile ester shipped by Riverdale from November 1964-November 1969 was 115,200 L. For 1962-1964. It was likely that the herbicide was shipped to Saigon and transported to Tan Son Nhut and Bien Hoa airbases, where the Base Civil Engineer had responsibility for base vegetation control. From 1965 to the close of the vegetation control program in 1971, it was the responsibility of PA&E for base vegetation control. At least four airbases received the commercial herbicides, i.e., Tan Son Nhut, Bien Hoa, Long Binh and Qui Nhon. No records were found that validated other Chemical Companies provided commercial herbicides to Vietnam or Thailand. The total volume of low volatile 2,4,5-T shipped to Thailand was 29,120 L. Distribution to the Royal Thai Airbases and subsequent vegetation control was the responsibility of PA&E. In their 1973 CHECO Report, Barnette and Barrow noted that the Royal Thai Air Force bases were receiving only the commercial herbicide Monuron (TELVAR®) for vegetation control [15]. At the height of the Vietnam War (~ 1968), approximately 50,000 American military were stationed throughout Thailand [21]. With the 1973 Paris Accords, US and remaining Allied Forces returned to their respective nations [21].

During the period from late 1964 through 1971, the spraying of the low volatile 2,4,5-T herbicide by PA&E on the Royal Thai Airbases (and Vietnam Airbases) on base vegetation likely resulted in little or no toxic exposure to US Military personnel assigned in Thailand. The available Riverdale records indicated they were never required to conduct chemical tests on their low volatile 2,4,5-T for the dioxin (TCDD) contaminant. However, the sources of their 2,4,5-T acid were analyzed by both Dow Chemical Company and Diamond Shamrock. For Dow the average dioxin content for the period 1965 to 1968 was 0.15 parts per million (ppm). For Diamond Shamrock the average for the period 1966 to 1969 was 1.50 ppm [22]. The mean dioxin level in Agent Orange was ~ 2.00 pm [22]. The difference however was that Agent Orange was aerially sprayed by USAF C-123B/K aircraft over the jungle and mangrove of Vietnam at the rate of ~30 kg/ha, while 2,4-D and 2,4,5-T were sprayed by PA&E at the rate of ~ 2.4 kg/ha directly on the vegetation. Bovey reported that in 1966, 2.3 million ha of rangeland and pasture were treated at the same of rate of ~2.4 kg/ha in the United States [23]. In addition, low volatile 2.4-D and low volatile 2,4,5-T were herbicides of choice on control of unwanted vegetation on most of the Department of Defense's more than 500 bases worldwide [12]. The Congress of the United States, the Department of Veterans Affairs, and the Thailand Veterans simply refused to accept the reality that little or no exposure to either tactical or commercial herbicides or TCDD ever occurred on Royal Thai Airbases in Thailand. The dilemma for the DVA is that to recognize Thailand veterans for commercial herbicide exposure fails to acknowledge that millions of military men and women were on hundreds of military bases that were sprayed with the same low volatile 2,4-D and 2,4,5-T commercial herbicides from 1962 -1972.

URL: http://dx.doi.org/10.14738/bjhr.1202.18415.

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