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PREVALENCE AND TREND OF OCCUPATIONAL DISEASES IN ARMY ORDNANCE EXPLOSIVES PLANTS DURING WORLD WAR II

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The material presented here represents a summary of a detailed report by the Ordnance Industrial Hygiene Branch on "Occupational Diseases and Their Control in Government-Owned Ordnance Explosives Plants During World War II". It is hoped that the complete report will be published in the near future.

This particular group of plants, numbering 101 and employing an average of over 300,000 workers, produced and loaded approximately 95 percent of all military explosives and large caliber ammunition, as well as 90 percent of small arms ammunition, made in the United States during the War period.

The nature of the operations giving rise to industrial health hazards varied widely in many of these plants and naturally fell into nine distinct types of industries, depending upon the type of manufacture or operation.

Shell and Bomb Loading Plants

From 17 to 20 of these plants were engaged in loading high explosives such as TNT, amatol, pentolite, tetryl, and other compounds into bombs, shells, mines, grenades, and rockets. These plants usually had additional lines where fuzes were loaded with detonating agents such as lead azide and mercury fulminate and with booster charges such as tetryl. Where complete rounds of ammunition were assembled, smokeless powder was used extensively, and double base powder containing nitroglycerine was used commonly for mortar shell increments and for propelling charges for rockets.

This industrial group, like all others, had sufficient maintenance shops to care for all equipment, buildings, and vehicles.

Because of the nature of loading operations, more employees were exposed by the open handling of dusty or fuming compounds and the toxic exposures were normally greater than in the other industrial groups. Consequently more attention and control measures for toxic exposures were required by loading plants than by any other groups.

High Explosives Manufacturing Works

This second industrial group consisted of from 11 to 15 plants engaged in manufacturing TNT, DNT, tetryl, penn, pentolite, RDX, and lead azide. TNT was the product common to all these plants. In addition, these plants manufactured nitric acid from anhydrous ammonia for their own use and many produced sulfuric acid from sulphur.

As many of these industrial chemical processes were enclosed and relatively few employees were needed for production operations, the problem of health hazards was much less serious than in the loading plants.

Smokeless Powder Works

Four or five plants, not counting those mentioned previously, were engaged in the manufacture of smokeless powder. Acids, nitrocellulose, diphenyl amine, and nitroglycerine, were manufactured as ingredients for smokeless powder, and one of the plants employed a few workers in the manufacture of TNT and tetryl, and another, dimethyl aniline. Ether-alcohol and DNT exposures were the principal health hazards in the manufacture of single-base powder, while nitroglycerine exposure was the chief hazard with double-base powder. The oxides of nitrogen offered a potentially serious exposure in the manufacture of nitric acid and in nitrating cellulose.

Miscellaneous Chemical Works

Ten plants were engaged in the manufacture of basic chemicals for explosives. Six of these manufactured anhydrous ammonia and the others produced ammonium picrate, ammonium nitrate, ammonia, picric acid, hexamine, formaldehyde, and methanol. The processes were largely enclosed and required relatively few workers.

Small Arms Ammunition Plants

From 4 to 12 plants were engaged in the manufacture of caliber .30, .45 and .50 ammunition, the number of plants being drastically reduced during the last year of the war.

Relatively few employees were exposed to toxic chemicals in the industry, and these were largely in segregated bays or work-rooms where tracer, igniter, or incendiary powders were pressed into hollow bullet cores. Many workers attended case and bullet draw machines which offered exposures to cutting oils and coolants. Also, there were sizeable numbers of workers engaged in soldering operations and in occupations involving solvents. The exposures to lead in the manufacture of bullets and in proof-firing were generally well controlled, as were those in mercury crack testing.

Bag Loading Plants

From 2 to 4 plants were engaged in making textile bags and in loading the bags with specified amounts of smokeless powder for fixed and semi-fixed artillery ammunition. The chief exposure was to black powder and to finished smokeless powder which contained small amounts of DNT. There were also the usual maintenance shops which offered the ordinary exposures to solvents and gases. No serious health hazard was encountered in these plants.

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Arsenals

The old line arsenals handling explosives were essentially peace-time developers

and producers of military ammunition and fire arms, and also renovated or modified sizeable quantities of obsolete or defective ammunition and equipment. A few had operated relatively small pilot lines for the experimental manufacture of explosives and for shell loading. These loading operations, however, were largely converted to other activities except for the loading of bursters for the Chemical Warfare Service, when full scale production was achieved in the new ammunition plants.

During this war 10 to 12 arsenals were engaged in the manufacture of tetryl, smokeless powder, pyrotechnics, small arms ammunition, artillery cartridge cases, artillery projectiles, time fuses, fire control instruments, and target material. In addition, a few of the arsenals were engaged in the loading of chemical and high explosive artillery and mortar shells. Several arsenals were engaged chiefly in the storage, maintenance, and issuance of Ordnance material while others had extensive facilities for repairing, modifying, and renovating equipment such as tanks, artillery, and optical equipment.

So far as the handling of explosives is concerned, the activities of the manufacturing arsenals provided a limited cross section of activities in the new ammunition plants, and the number and degree of toxic exposures varied considerably from one arsenal to another.

Depots

From 13 to 18 Ordnance Depots were engaged in the receiving, storing, and issuance of ammunition and explosives. In general, the old line depots only received, stored and issued explosives and ammunition, and performed any necessary renovation and modification of defective or obsolete ammunition. Limiting loading of TNT was done for a short period in two of these depots, but the total number of exposed workers did not exceed 300.

The newly built depots received, stored, and issued Ordnance general supplies in addition to ammunition and explosives. There were also extensive tank repair and modification operations, and in several of the depots there were sizeable numbers of employees engaged in the repair and modification of artillery and optical equipment.

The occupational exposures to toxic explosives was not a major problem in the depots. On the other hand, the extensive repair and modifying operations in Ordnance material meant that many workers were exposed to potentially hazardous concentrations of solvents, paints, cutting oils, and related chemicals.

Proving Grounds

Six proving grounds, including one small ballistics laboratory, were engaged in the proofing of developed types of ammunition, research on new types of ammunition, modification of artillery, and the proof-testing and acceptance-testing of all types of weapons including bombs and mines.

While very few of the workers were regularly exposed to TNT, there were many and varied exposures from proof-firing of ammunition to atmospheric contaminants including carbon monoxide, lead, nitroglycerine, and nitrogen oxides, and from the cleaning, de-greasing, and painting of Ordnance material including solvents, paints, and cutting oils.

This brief description of the operations carried out in these nine industrial groups, and a listing of the majority of toxic substances offering potential exposures, indicate to some extent the health problems involved and the necessity for strict control measures.

Although the industrial dermatoses from contact with materials, such as tetryl, TNT, DNT, fulminate of mercury, ammonium nitrate, antimony sulfide, and a large variety of solvents, far exceeded the definite occupational intoxications, the latter were much more serious. Among the more common offenders presenting potential toxic exposures were TNT, either alone or in combination with other explosives in the form of a dust, fume or vapor, depending upon the particular operation; the nitrogen oxide gases; and a number of the more familiar atmospheric contaminants, including lead fumes and dust, mercury vapors, metal fumes of all kinds in metallizing operations, and vapors of volatile solvents in degreasing, decarbonizing, and paint spraying operations.

Adequate medical facilities and services for the protection of the health of workers were provided in each plant. As a further precaution against accidents and occupational diseases, the Chief of Ordnance, Lieutenant General Levin H. Campbell, Jr., established the Safety and Security Division which was charged with taking "the steps necessary to insure the safety and security of specific plants, facilities, and installations assigned to the Chief of Ordnance in which explosives, propellants, or their ingredients are manufactured, processed, or stored." Personnel from the Army Medical Corps and U. S. Public Health Service was detailed to the Division in October 1942 for the purpose of coordinating the safety activities with the industrial health and hygiene activities of the Army Medical Department, and for supervising and prompting an aggressive industrial hygiene program in these plants.

As a means of determining the nature and extent of toxic exposures in these plants, industrial hygiene surveys were made by either the Army Industrial Hygiene Laboratory or the U. S. Public Health Service about every six months in the plants presenting more serious health hazards, and about once yearly in the other plants.

Personnel from the Ordnance Industrial Hygiene Branch of the Safety and Security Division made the necessary follow-up visits to insure compliance with all recommendations, and also conducted special studies in all plants from time to time as new problems developed. Technical consulting services were made available on all health problems.

Several meetings were organized with the Medical Directors or Post Surgeons of the various plants for conferring and bringing together all recent information on troublesome subjects such as TNT and nitrogen oxides poisoning. These conferences resulted in a clearer understanding of the health hazards involved in various plant operations and in a more uniform and simplified procedure for laboratory work in connection with periodic examinations of workers. The transactions of these meetings, containing recommended policies for controlling occupational diseases, and circulars containing information on pertinent health subjects were distributed to all plants.

Each plant was required to send to the Division complete occupational disease reports. Each report included the average number of employees for the period engaged in production or operations, the average number exposed to TNT and the number of cases of general or systemic poisoning and dermatitis resulting from TNT, tetryl, nitrogen oxides, solvents, cutting oil, and other specified exposures. These cases were further classified as fatalities, lost-time or disabled cases, mild or non-disabled cases, and medical transfers.

The reports for the first period (through February 1943) supplied all data from the beginning of World War II production, but not prior to June 1, 1941 in the case of plants that had been operating during peace-time. In most plants, this would mean from the beginning of war production, and in the old-line arsenals, it would approximate the beginning of expanded national defense activities. The reports covered

production periods ranging all the way from one to twenty-one months, the weighted average being 8.6 months, taking into consideration the varying numbers of employees in each plant.

From here on the reports were sent out for completion at intervals of four months, excepting one period, the fourth, when administrative difficulties delayed the reporting procedure for two months which resulted in one five-month period. There were a total of ten report periods covering an average of more than thirty-seven months of operations. Because of the long first period and the five months in the fourth period, it was not possible to calculate case rates for occupational disease as percent, or per 1000 or 10,000. Likewise, the accepted practice of safety men in reporting so many disabling injuries per million man hours of work means little to medical men and others in the industrial hygiene field, as this concept is difficult to visualize by those not engaged in accident reporting. Accordingly, the occupational disease rates were determined per 1000 man-years of production, or in the case of TNT poisoning, per 1000 man-years of actual exposure, taking into due consideration the length of each report period covered. This figure is equivalent to the potential exposure of 1000 men for one year, or 4,000 men for one quarterly period, and equalizes the irregularity of duration of the report periods.

In a total of 968,000 man-years of operations, there were only 28 occupational disease fatalities - 22 from TNT (eight of these died of toxic hepatitis, 13 of aplastic anemia, and 1 of a combination of the two conditions), 3 from nitrogen-oxides, 2 from carbon tetrachloride, and 1 from ethyl ether — a rate of less than 3 fatalities per 100,000 workers per year. Of these 28 fatalities, only 6 occurred in the last 18 months of the war. The total of 22 TNT fatalities reported here is but a small fraction of the 475 fatalities reported from TNT or related compounds during limited production in World War I.

Among all operating employees in all plants, there were only 2.4 cases per 1,000 man-years of production of occupational illness and dermatitis sufficiently severe to lose time from work. The quarterly rates were reduced from a peak of 3.8 in the spring of 1943 to an average of 1.4 for the last year of operations - a decrease of 63 percent, despite a great increase in production. Dermatitis accounted for two thirds of these lost-time cases, which leaves the more serious general or systemic type of poisoning with an overall rate of less than one (0.8) case per 1,000 man-years of production.

Mild or non-disabled cases of occupational diseases were reported along with the lost-time cases. These often consisted of only minor complaints at the first-aid station or of slight changes in laboratory findings during periodic examinations, and were usually of little significance from a medical viewpoint but served as an additional index as to the scope of the problems involved and the success of the control program. The trend and distribution of mild cases resulting from different exposures were very similar in pattern to the lost-time cases. Among all operating employees in all plants, the mild case rate from all exposures dropped rapidly from a peak of 124 per 1,000 man-years of operations in the first report period to an average of 59 for the last three periods - a reduction of more than half.

Workers showing sufficient symptoms of toxic exposure were transferred to other jobs by the plant medical departments as a precaution against disabling illness until the exposures could be controlled more effectively. The transfer cases were drawn largely from the two previous groups and were generally of little significance. Better control of the exposures and personal hygiene reduced the need for medical transfers, resulting in more efficient production and a marked saving in costs.

The rate of medical transfer for all exposures in all plants dropped from a peak of 44 per 1,000 man-years of operations in the third report period to an average of 22.5 for the last four report periods - a reduction of almost half, and despite a great increase in production. It is believed that, from an economic viewpoint alone, this reduction in the need for transferring workers away from their jobs more than justified the whole industrial hygiene program.

Occupational illnesses were also grouped according to the causative agent. For example, in the Shell and Bomb Loading Plants, which employed a total average of 76,000 operating employees, of whom an average of about 16,700 actually were exposed to significant quantities of TNT fumes or dust, the lost-time case rates fell from a peak of 29 per 1,000 man-years of exposure in the spring of 1943 to an average of less than 8 for the last 6 quarterly report periods - a reduction of over 70 percent despite a great increase in production.

In the TNT manufacturing works, among an average of 5,600 TNT exposed employees, the rates for lost-time TNT cases declined from a peak of 12.7 per 1,000 man-years of exposure in the first report period, to an average of less than 2 during the last 7 report periods - a reduction of 85 percent.

Similar improvement was noted in the control of mild or non-disabling cases and in the number of transfers. The complete report, when available, will show the plant experience for all occupational diseases. So far as is known, this is the first large scale demonstration of what an aggressive industrial health and hygiene program can accomplish by preventing illness and conserving manpower in a large industry presenting exposures to many poisonous compounds.

During more than 37 months in World War II, despite the difficulties associated

with rapidly increasing production of explosives, unskilled labor, a fairly high labor turnover, and frequent changes of production processes and schedules, a very marked reduction was effected in the prevalence of occupational disease fatalities and disabling and non-disabling illnesses, and in the transferal of workers away from their regular jobs because of occupational diseases.