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Summary of Past Test Projects

1. The Ophthalmological Survey Group studying the Hiroshima and Nagasaki casualties investigated the subject of the impairment of visual acuity following the two detonations. No case of dazzle effect which lasted for more than about five minutes was found among the survivors. In one group of 1,000 individuals within 2,000 yards of ground zero, no lesions were found in the retina which were believed to be directly related to the atomic bomb. In those cases in which dazzle effect was reported, the survey data did not permit analysis on the basis of distance from or orientation toward the point of detonation.

2. At Operation BUSTER, 1951, a group of daylight-adapted individuals positioned in an aircraft orbiting at 15,000 feet altitude, nine miles from ground zero, looked directly at the flash and then read test charts to check visual acuity. Unprotected test subjects encountered temporarily impaired vision ranging from less than 20/400 to essentially normal vision immediately after the flash; however, all recovered within two minutes. Other subjects in the aircraft facing 180° away from the flash experienced no visual impairment. It was concluded that, generally, light-adapted subjects were not seriously handicapped by the nuclear flash at the distance at which they were exposed. The yield involved was 14 KT.

3. At Operation SNAPPER, 1952, dark-adapted individuals in a light-tight trailer located ten miles from ground zero and oriented directly toward the burst observed the flash either through red filters or with the eyes unprotected. It was found that unprotected subjects regained good central acute (daytime) vision in approximately 132 seconds while those using red filters required 111 seconds to regain the same degree of vision. Immediately after exposure, subjects described a large white or yellow temporary blind spot. This gradually diminished in size until six minutes after exposure, when it was difficult for the subjects to outline the area. The yields involved were 11 and 14 KT.

4. At Operation UPSHOT-KNOTHOLE, 1953, subjects in a light-tight trailer were exposed to a total of five shots at distances varying from seven to fourteen miles. These individuals were dark-adapted and oriented toward the fireball. Protection was afforded by filters which cut down irradiance to 20-25 per cent of the total incident at the eye. Following exposure, subjects were tested for return of acuity. Reasonably good central acute vision (20/40) was recovered by an average time of 153 seconds. Under lighting conditions approximating those of a moonless night, peripheral (night) vision was regained in the same time interval. The purpose of this test was to determine the degree of protection from dazzle effects provided by combined infrared absorbing and red transmitting filters. The many variables encountered in the test prevented the determination of this factor with any degree of accuracy.

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5. At Operation REDWING, 1956, the objective was to obtain information on the requirement for protection of the eyes against chorioretinal burns from atomic detonations of various yields. Rabbits and monkeys were used as test subjects with the following conclusions:

a. Chorioretinal burns are produced at distances greatly exceeding those for any other prompt and significant biological effects of nuclear detonations. The problem of chorioretinal burns is one of increasing significance at higher altitudes, where the rate at which the bomb delivers its radiant energy is increased and the lack of atmospheric attenuation increases the radiant exposure at a given distance, or increases the distance to which a given amount is transmitted.

b. It was noted that the distance to which retinal burning is produced in the Pacific Proving Ground is less than at the Nevada Proving Ground, where burns were encountered at distances as great as 42.2 miles from ground zero. The lesser range at the PRG is attributed to the high atmospheric attenuation due to excessive humidity.

c. The blink-reflex time for rabbits, monkeys and man is not sufficient to protect against the flash from devices of small and intermediate yields.

d. Fixed-density optical filters reduce the caloric dose and dose rate incident on the eye and, therefore, the incidence of chorioretinal burns.

6. At Operation PLUMBBOB, 1957, subjects were exposed using goggles with shutters both operating and not operating in order to determine the extent of protection from dazzle effect afforded through shutter closure. The distance involved was approximately eighteen miles. Return of central acute vision required up to ninety seconds.

When a translucent glass plate was employed between the light source and the eye, so that it acted as a secondary light source, with subjects located at a distance of 10 miles from the point of burst with eyes unprotected, it was found that the vision was more acutely affected than when the eye was exposed to direct energy. The recovery time to partial vision is shorter when the direct light source is viewed, but the possibility of permanent damage is great. When the light is viewed through a secondary source the possibility of permanent damage is virtually non-existent, due to lack of image formation, but the glare effect is found to be all encompassing, and the individual is completely blinded by dazzle effect for a period of time. Yields involved in this test ranged from 10 to 70 KT.

7. At HARDTACK Phase I, 1958, with rabbits as subjects preliminary data indicates:

a. A 4 MT detonation at 250,000 feet delivers approximately 90 per cent of its thermal component during the first 100 milliseconds of explosion. Consequently, with a blink-reflex time of 100-150 ms for man,

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all the radiant dosage from a very high altitude burst is received by the retina before the eye can be protected by blinking. This is in contrast to low altitude detonations of the same size, where the power pulse is markedly bi-phase and comparatively much slower in the overall delivery of its thermal component.

b. Minimal chorioretinal burns can be received by an observer at sea level at distances closely approaching 300 nautical miles from a 4 MT detonation at 250,000 feet, with a correspondingly greater distance if the observer is also at high altitude.

c. The lesions produced at all exposure stations within 60 nautical miles were of sufficient size and severity to result in permanent retinal damage with severe loss of visual acuity.

d. No double or dumbbell-shaped lesions were observed. The absence of this type of lesion in the present case attests to the extremely high rate of thermal energy of the very high altitude explosion. Dumbbell-shaped lesions are observed when a lower rate of delivery of thermal energy occurs, allowing time for the eye to be moved and re-focused.

8. At Operation HARDTACK Phase II, 1958, the objective was to evaluate the dazzle effect on unprotected daylight-adapted combat personnel from a very low, fractional yield nuclear detonation at minimum safe distance. Subjects were in three groups oriented at 90°, 135°, and 180° away from ground zero at a range of 5,700 feet. The results were that none of the personnel experienced any dazzle effect as a result of the detonation.

9. To date there have been four cases of accidental retinal burn to humans. One case occurred in Operation SNAPPER at a distance of 10 miles from a 20 KT air burst, and three cases in Operation UPSHOT-KNOTHOLE, two at distances of 7-10 miles from a 44 KT detonation and one at 2 miles from a 27 KT burst.

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