COMPARISON TEST OF DRIVERS NIGHT VISION DEVICES, M60 SERIES

Army Armor and Engineer Board
Fort Knox, Kentucky

9 April 1973

DEPARTMENT OF THE ARMY LT Goetzke/bw/464-4349
UNITED STATES ARMY ARMOR AND ENGINEER BOARD
Fort Knox, Kentucky 40121

9 APR 1973

STEBB-TD-A

SUBJECT: Final Report of Comparison Test of Drivers Night Vision Devices, M60 Series, TECOM Project No 1-VC-089-060-005

Project Manager - M60 Tanks
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1. REFERENCES

a. Msg, 2-5020, AMCPM-M60-T, PM M60 Tanks, 211300Z Feb 73, subject: Request for TECOM Evaluation of Drivers Night Vision, M60 Series Tanks.

b. Ltr, AMSTE-BB, TECOM, 22 Feb 73, subject: Customer Test Directive: Evaluation of Drivers Night Vision Devices, M60 Series, TECOM Project No. 1-VC-089-060-005, w 1 incl.

c. USAARENBD Test Outline, Comparison Test of Drivers Night Vision Devices, M60 Series, TECOM Project No 1-VC-089-060-005, 20 Mar 73.

d. Ltr, AMSEL-NV-SD, ECOM, NVL, 1 Mar 73, subject: Safety Statement, AN/VVS-2( ) (V).

e. Ltr, AMSEL-SF, ECOM, 9 Feb 73, subject: Safety Statement, AN/PVS-5, w 3 incl.

2. RESPONSIBILITIES. The Armor Test Branch of the US Army Armor and Engineer Board was responsible for test planning, test execution, and test reporting.

3. BACKGROUND

a. The Driver's Viewer, Night Vision, AN/VVS-2 was designed and developed to meet one of the provisions of the 1964 QMR for night vision equipment for combat vehicles. In 1968, the first passive driver's viewer was developed under the SEANITEOPS Program using first generation image intensifier technology. The present system, an advanced development model, utilized second generation image intensifier technology.

b. The Night Vision Goggles, AN/PVS-5 were designed and developed to meet a provision of the 1964 QMR for Individual Night Vision Aids. The system is an improved model of the Electronic Binoculars (SU-50). During April-June 1972, the night vision goggles underwent a military potential test at Fort Benning, Georgia. In December 1972, the system was subjected to a user evaluation by Project MASSTER, Fort Hood, Texas. On 10 January 1973, an in-process review was held to determine the future of the Night Vision Goggle Program. As a result of this IPR, the AN/PVS-5 was directed to undergo additional testing.

c. On 21 February 1973, Project Manager, M60 Tanks, requested that TECOM evaluate the Driver's Night Vision Viewer, AN/VVS-2 and the Night Vision Goggles, AN/PVS-5 to obtain relative performance information which will be needed to form an AMC position on drivers' night vision requirements for forthcoming IPR on a universal drivers' viewer, scheduled for May 1973 (ref 1a).

d. USAARENBD was directed to run a three-way comparison test of drivers' night vision devices to include: the Driver's Night Vision Viewer, AN/VVS-2; the standard M24 driver's infrared periscope; and the Night Vision Goggles, AN/PVS-5, used as a driver's night vision device in both open and closed-hatch modes. All testing was to be conducted using three kinds of night lighting conditions: infrared, natural, and "pink" light. Authority for the conduct of this test is contained in the test directive, ref 1b.

e. The USAARENBD was furnished two Driver's Viewers, Night Vision, AN/VVS-2, and three pairs of Night Vision Goggles, AN/PVS-5 for test. The standard M24 infrared periscopes and the M60A1 tanks were supplied from USAARENBD assets. In addition, one set of specially developed pink filters were mounted on one vehicle's white headlights during testing.

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4. DESCRIPTION OF MATERIEL

a. The Driver's Viewer, Night Vision, AN/VVS-2 test item uses one 25mm second generation image intensifier tube, high quality lenses, a fiber optic expander, and a biocular eyepiece. The viewer consists of three major assemblies: the eyepiece assembly; the image intensifier tube assembly; and the objective assembly. Power is supplied by a 2.75 volt self-contained battery. (See photograph, page 2, inclosure 1.) (Although an adapter to enable it to run off the vehicle power supply is under development, none is available at this time.) The technical characteristics are as follows:

System Parameters

Magnification	1X
Field of View	45° Circular
Resolution	1 lp/mr
Eyepeice Focus	-2.0 diopter fixed
Objective Focus Range	15 ft to infinity
Power Supply	2.7 VDC Battery
Weight	20 lb
Size	17" x 5" x 5"

Objective Lens

Focal Length	34.21mm
T-No	1.46

Eyepeice Lens

Focal Length	56
Power	5
Exit Pupil	88mm
Eye Relief	50mm

b. The Night Vision Goggles, AN/PVS-5 test item, uses two 18mm, second generation, wafer type, image intensifier tubes, high quality lenses, and a fully adjustable face mask. It includes adjustable focus objective and eyepiece lenses and an IR Diode for supplementary illumination. (See photograph, page 1, inclosure 1.) The technical characteristics are as follows:

System Parameters

Magnification	1X
Field of View	40°
Resolution	0.67 Lp/mr

System Parameters

Diopter Range	+2 to -6
Focus Range	10" to infinity
Power Supply	2.7 VDC Battery
LED	
Peak	8300 + 200 Å
Half Power Bandwidth	400 Å
Power Output	2mW
Current Drain	
wo Diode	24ma
w/Diode	39ma
Weight	2.0 lb
Size (In Mask)	6.8" x 6.5" x 4.5"

Objective Lens

Focal Length	27mm
T-No	1.4

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Eyepiece Lens

Focal Length	27mm
Power	9.4
Exit Pupil	10mm
Eye Relief	15mm

5. TEST OBJECTIVE. To determine relative performance of drivers' night vision devices for M60 series tanks.

6. SUMMARY OF RESULTS. Comparison testing of the AN/VVS-2 test item and the AN/PVS-5 test item with the standard M24 driver's infrared periscope was conducted during the period 5-30 March 1973. Testing was accomplished in accordance with the test outline (ref 1c).

a. Preoperational Inspection

(1) The five test items were complete and in an operable condition upon arrival. No faults were noted.

(2) Photographs of the test items are at incl 1. The weight of the AN/VVS-2 and AN/PVS-5 test item was 20 lb and 2.0 lb, respectively.

b. Installation and Stowage

(1) Prior to the start of testing, the drivers received familiarization instructions on the test items. This instruction was conducted by the Night Vision Laboratory representative. After the instructions, the drivers operated the test items on cross-country terrain and secondary roads. The three sets of AN/PVS-5 goggles were operated for 17 hours and over courses totaling 40.3 miles. The AN/VVS-2 viewers were operated for 4.5 hours and over courses totaling 20.3 miles. No difficulties were recorded as to the drivers' abilities to absorb the training.

(2) The AN/VVS-2 passive viewer cannot be stowed in the present M24 periscope stowage container of the M60A1 tank. Modification of the container is necessary. No other stowage area was examined. The AN/PVS-5 goggles, secured in their carrying case, can be adequately stowed in the M60A1 oddment tray.

(3) The AN/VVS-2 passive viewer can be mounted in the currently configured driver's hatch, however, modification to the hatch insert lid is required in order to achieve optimum periscope use. The stop on the hinge assembly eliminates the elevation capability of the AN/VVS-2 passive viewer. For purposes of testing, the lid was removed. After the modification, no mechanical difficulties were recorded as pertained to the driver's hatch and the driver's compartment components. Mounting and dismounting of the AN/VVS-2 passive viewer was done by the drivers while inside the vehicle. No assistance was required by any of the drivers.

c. Functional Suitability

(1) During testing, the five test items were operated using standard 2.7 volt mercuric batteries as power sources. The AN/VVS-2 is capable of being operated using the M60A1 electrical system, however, this was not done due to a lack of adaptive hardware. Throughout the test period, the only maintenance performed on the test items was cleaning of the optics and test items by the drivers.

(2) Due to time restraints, the horizontal and vertical fields of view and the depth perception subtests were not conducted.

(3) One incident of lens fogging on the AN/PVS-5 goggles was recorded. The temperature was 35° and the relative humidity was 96 percent. The incident was rectified by installing the demist shields supplied with the goggles. No other incidents of fogging were recorded.

(4) The test and comparison items were used to operate vehicles over six predetermined courses under various light conditions. Each course was traversed by three drivers. Two courses were cross-country, two courses were secondary roads, and two courses were a combination of unimproved trails and secondary roads. Each of the six courses was 1 mile. Sequencing of the drivers, the night vision devices, and the lighting conditions was alternated so as to equalize the effects of relative capabilities. The times of each driver on each course under each light condition and each night vision device used was recorded. (See incl 2.)

(5) On all runs through the courses, the vehicle commanders had been instructed not to assist the drivers unless he left the course or requested assistance, or an unsafe driving condition existed. In the AN/PVS-5 goggles, closed-hatch configurations, the drivers were assisted by the vehicle commander on 19 of 54 runs. Because of this excessive number of unsuccessful runs, no computations have been performed on the AN/PVS-5, closed-hatch configurations, as statistical

analysis was not required to differentiate between the relative performance of the AN/PVS-5 goggles, closed hatch, vis-a-vis the M24 IR periscope, the AN/VVS-2 passive viewer, and the PVS-5 goggles, open hatch. The only other configuration under which the drivers required assistance (3 of 18 runs) was the M24 IR periscope. However, these data have been used in spite of these three unsuccessful runs as the computations indicate, that regardless of the inclusion or exclusion of these three runs, the M24 IR performed substantially below all the other configurations. Therefore, it can remain as an effective baseline measure for evaluating relative performance. The M24 IR mean time computation was computed using only the 15 successful runs.

(6) The mean times for the three drivers to traverse the six courses under each of the 10 test configurations are as follows:

	(Minutes:Seconds)
M24 periscope with infrared illumination	6:33
AN/VVS-2 without illumination	3:59
AN/VVS-2 with pink light illumination	3:43
AN/VVS-2 with infrared illumination	4:03
AN/PVS-5 without illumination (closed hatch)	Not computed due
AN/PVS-5 with pink illumination (closed hatch)	to unsuccessful runs
AN/PVS-5 with infrared illumination (closed hatch)	"
AN/PVS-5 without illumination (open hatch)	3:35
AN/PVS-5 with pink light illumination (open hatch)	3:28
AN/PVS-5 with infrared illumination (open hatch)	3:25

None of the courses were run during inclement weather.

(7) The statistical comparisons of the above mean times using a one-sided t'-test at 95-percent confidence was calculated using the M24 periscope with infrared illumination as baseline data. The applicable procedures are outlined in "Experimental Statistics Handbook 91" National Bureau of Standards, October 1966, page 3-34. In each calculation, the M24 baseline mean time exceeded the six

comparison configurations at the 95-percent one-sided confidence level. The extent that the M24 mean time exceeded the mean time of the six configurations is listed below. The number shown after each configuration is the minimum number of seconds per mile that the M24 mean time can be expected to exceed the other test configuration mean times:

	Per Mile
AN/VVS-2 without illumination	91.8 seconds
AN/VVS-2 with pink light illumination	108.4 seconds
AN/VVS-2 with infrared illumination	86.9 seconds
AN/PVS-5 without illumination (closed hatch)	Not Computed
AN/PVS-5 with pink light illumination (closed hatch)	Not Computed
AN/PVS-5 with infrared illumination (closed hatch)	Not Computed
AN/PVS-5 without illumination (open hatch)	116.4 seconds
AN/PVS-5 with pink light illumination (open hatch)	122.9 seconds
AN/PVS-5 with infrared illumination (open hatch)	125.8 seconds

(8) Using the statistical technique outlined above, a two-way comparison between the mean time for the AN/VVS-2 without illumination and the mean time for the AN/PVS-5 without illumination (open hatch) was computed. The times of the AN/PVS-5 (open hatch) and the AN/VVS-2 are such that it cannot be said at the 95-percent confidence level that the average time of one will be less than the average time of the other.

(9) Using the statistical technique outlined in subparagraph (5) above, a comparison between the mean time for the AN/PVS-5 without illumination (open hatch) and the mean time for the AN/PVS-5 with pink light illumination (open hatch), was made to check the effectiveness of the pink light illumination. The calculations indicated that it could not be said at the 95-percent confidence level that the average times of one would be less than the average time of the other.

(10) Driving with the AN/PVS-5 goggles in the closed-hatch mode under all light conditions was difficult. The drivers reported that they could not see through the vision blocks (M27 driver's periscope). The vision blocks reflected light from the red lights found in the driver's compartment and the turret as the reflected light from inside the tank was magnified by the goggles. To overcome the difficulty, the following procedures were adopted:

(a) All lights inside the tank that could be were turned off or covered in an attempt to alleviate the problem. The lights extinguished included all dome lights, panel lights, gunner's control lights, and radio lights. The remaining lights were the battery light and the IR warning light (when activated).

(b) Further, the surfaces of the vision blocks were completely cleaned after short intervals of time and distance (the time necessary to negotiate the 1-mile course).

(c) Finally, the driver had to position his head in such a manner that the eyepieces of the goggles were within 1 or 2 inches of the vision block. On two occasions when the procedures were not followed, the drivers ran off their courses and threw tracks.

(11) A subtest was conducted to determine the maximum and minimum ranges at which the test and control devices could identify oncoming vehicles. Each system was presented with only nine targets (due to time and support vehicle restrictions). The chart below lists the range band within which the three operators, using the test and control items, could differentiate between an M151 1/4-ton truck and a M715 1-1/4-ton truck:

Night Vision Device	Range Band at Which Target Initially Identified
AN/VVS-2 Passive Viewer	400 - 600m
AN/PVS-5 Goggles (open hatch)	400 - 500m
AN/PVS-5 Goggles (closed hatch)	375 - 550m
M24 IR Periscope	25 - 75m

Test was conducted under moonlight conditions and all target vehicles were completely blacked out.

(12) Convoy operations were conducted under moonlight conditions on secondary roads. Each of the test and control items were used in the convoy operation. No difficulties were encountered by either the lead tank or the trail tanks. The vehicles in convoy did have to stay out of the dust cloud raised by the preceding vehicle. (Short duration of test precluded performance of tactical exercise.)

(13) An evaluation of the effects of night firing tank armament was not conducted. The effects of bright, white lights were subjectively evaluated by all drivers. The three drivers concluded that their ability to drive was adversely affected by the oncoming bright lights. In each case, the resolution of the test device's image was lost to the driver until he had gone beyond the white light source. Once beyond the light source, each was able to continue driving without any residual effects.

(a) In order to illustrate the effects of bright, white light on the performance of a driver using the systems, one driver negotiated a 1-mile road course with each test item under ambient conditions, and again with three critical points illuminated by oncoming vehicle headlights. The times for each run were recorded and are listed below:

Test Device	Time Required to Complete Course Ambient Light	 Ambient Light/White Light Obstacles
AN/VVS-2	2:45 (Min/Seconds)	5:12
AN/PVS-5 (open hatch)	2:47	4:04
AN/PVS-5 (closed hatch)	3:03	8:40

(The above chart is displayed merely to illustrate the effects of bright lights and is not statistically adequate for comparison.)

(b) In each instance, oncoming vehicle headlights adversely affected the driver's ability to see and the vehicle commander had to assist the driver to stay on the road.

d. Security

(1) The test items did not interfere with the parent vehicle's radio.

(2) The test items are light secure. When they are properly employed, the parent vehicle is no more susceptible to detection by

binoculars or unaided vision than it would normally be at night. Each of the three test items was mounted in turn on an M60A1 tank. Observers were placed down range from the tank and were instructed to attempt to detect the tank using M17 binoculars and normal unaided vision. In all instances, the observers detected the tank rather than light emitting from the test items. Any differences in ranges were attributed to different light levels which occurred during the conduct of the exercise.

(3) Drivers using the AN/VVS-2 passive viewer and the AN/PVS-5 night vision goggles detected an M24 IR equipped tank at a greater range than did drivers using M24 IR periscope detect the tank equipped with the test items. Drivers using the AN/VVS-2 passive viewer detected the infrared lights of a tank using the M24 IR system at 2,000 meters, which was the limit of the test range. The same drivers using the Night Vision Goggles, AN/PVS-5, detected the M24 infrared lights att 1,875 meters in the open-hatch mode, and at 1,850 meters in the closed-hatch mode. The observers using the M24 IR periscope did not detect the tanks on which the two passive systems were employed until they were within 100 meters.

(4) Observers attempted to detect a tank equipped with "pink" light headlights activated. They used normal unaided vision, M17 binoculars, and image intensifiers (night vision goggles and the passive viewer). As a result of this exercise, it was determined that the pink light did not pose a security threat to the parent vehicle, unless observers were equipped with image intensification devices. Observers equipped with image intensifiers detected the pink light at the same range that they detected infrared headlights, i.e., 2,000 meters (maximum range available).

e. Safety and Human Engineering

(1) Throughout testing, all safety procedures required by the safety statements (references 1d and e), operators' manuals, and other pertinent documents were followed.

(2) Two of the three test drivers preferred the AN/VVS-2 passive viewer (which can only be used in the closed hatch, since it is a periscope) over all other systems. The third driver preferred the AN/PVS-5 goggles but only in the open-hatch mode. All three drivers were dissatisfied with the AN/PVS-5 goggles in the closed-hatch mode, preferring them only over the M24 IR system. Their choices were based on ease of use, confidence in the system, and comfort.

(3) Controls on test items are conveniently located, sensitive to touch, and easily identifiable in darkness.

(4) The three drivers felt that only the M24 impaired their depth perception to the extent that they felt insecure while driving. They felt that both the test items and the comparison item gave them a false sense of speed. They judged their speed to be less than that which it actually was. However, they felt that this speed deception problem could be overcome through training.

(5) Two of the three drivers felt that the AN/VVS-2 passive viewer afforded the best field of view. The third driver preferred the AN/PVS-5 goggles in the open hatch. None experienced any difficulties in negotiating any of the courses or terrain encountered during the test because of limited field of view or blind spots.

(6) None of the drivers felt that there were any safety hazards associated with operating the test and comparison items. Further, the items introduced no unsafe conditions in the performance of normal driver functions, e.g., checking instrument panels or warning lights. Drivers using the AN/PVS-5 goggles lifted them away from their eyes when performing the checks. The effects of oncoming bright lights were not felt to be hazardous as the vehicle's commander was available to assist the driver.

(7) No difficulties were experienced by the drivers in operating the test items and comparison item while wearing military gloves.

(8) One recommended improvement was suggested for the AN/VVS-2 passive viewer. The viewer in its current configuration cannot be easily adjusted for focus. It was recommended that the focus adjustment be external vis-a-vis internal.

(9) The drivers stated that they did not need to use the protective rubber eyeguard supplied with the AN/VVS-2 passive viewer. They preferred not to use it.

2 Incl
as

JOHN P. BERRES
Colonel, Armor
President

Copies furnished:
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Cdr, ECOM, ATTN: AMSEL-NV-SD (Mr. Oswalt) (in dupe)
Cdr, USAARMC
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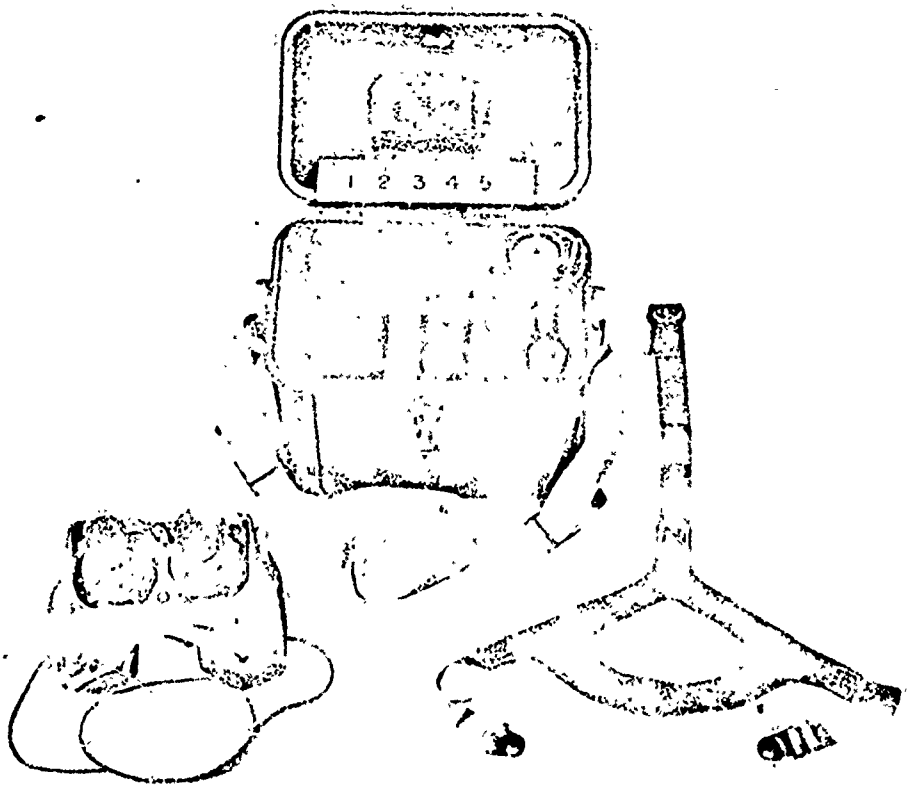

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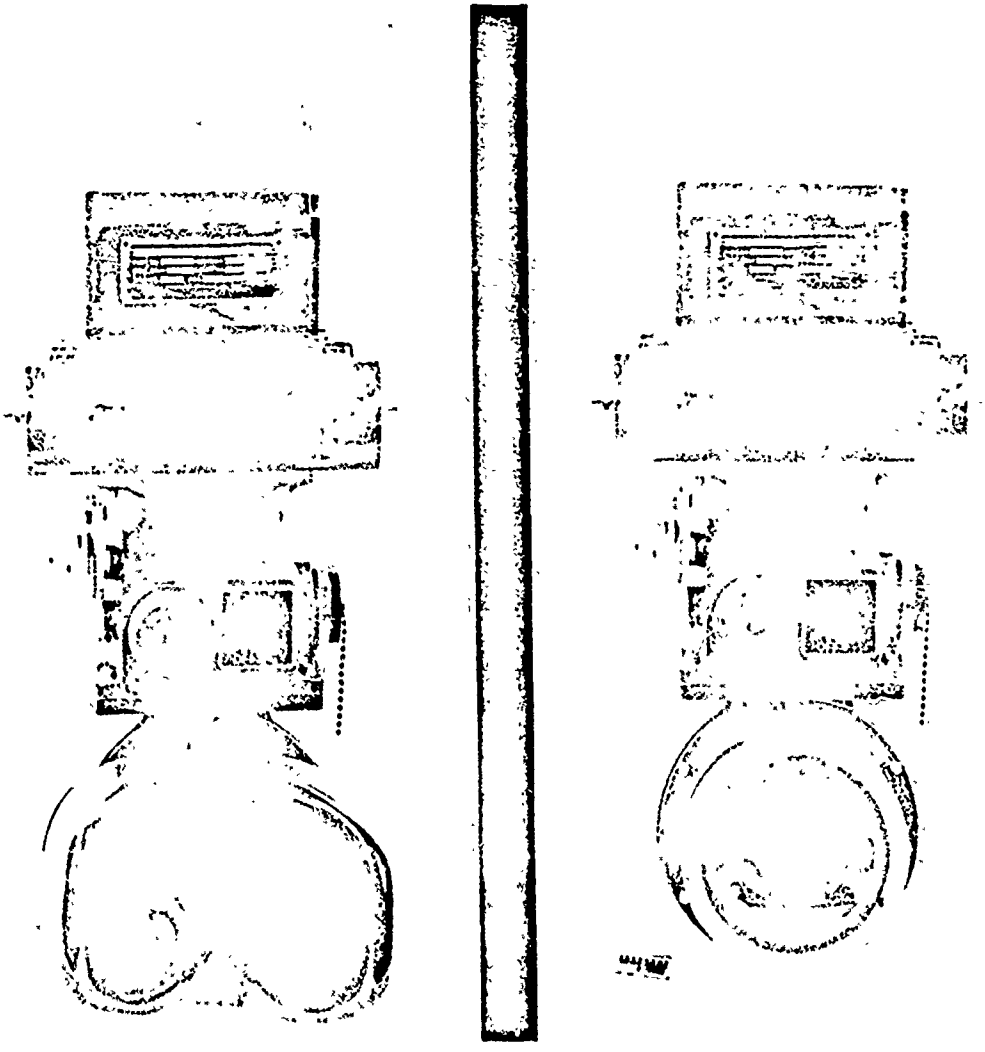
DRIVERS' NIGHT VISION DEVICES, M60 SERIES

AN/PVS-5 NIGHT VISION GOGGLES
WITH CARRYING CASE AND ACCESSORIES

INCL 1



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DRIVERS' NIGHT VISION DEVICES, M60 SERIES

AN/VVS-2 DRIVERS' VIEWER, NIGHT VISION (RIGHT)

AN/VVS-2 DRIVERS' VIEWER, NIGHT VISION WITH PROTECTIVE EYE GUARD (LEFT)

INDIVIDUAL RUN TIME (MIN:SEC)

Device/ Lighting	M-24 IR	VVS-2 Ambient	VVS-2 Pink	VVS-2 IR	PVS-5(c) Ambient	PVS-5(c) Pink	PVS-5(c) IR	PVS-5(o) Ambient	PVS-5(o) Pink	PVS-5(o) IR
Dvr/Crs										
Wallacke/1	5:00	3:45	3:20	3:58	7:01	3:32	7:02	4:06	2:57	3:05
/2	5:00	4:23	4:55	3:36	5:14	5:52	6:06	4:50	5:17	5:14
/3	7:46	3:30	2:50	4:00	3:11	2:40	2:49	3:45	2:43	3:02
/4	5:55	3:24	3:31	3:22	3:30	4:19	4:10	3:32	3:26	3:18
/5	3:05	3:30	2:49	2:58	3:05	3:00	2:40	2:27	2:24	2:26
/6	6:22	4:25	3:47	4:20	4:43	3:57	7:35	3:34	2:40	3:17
High /1	10:00	3:12	4:25	3:55	4:40	3:15	8:00	3:56	3:05	3:16
/2	11:00	4:25	3:55	6:14	4:55	8:15	8:11	4:15	5:09	3:21
/3	8:52	2:45	2:43	2:40	3:03	3:07	3:45	2:47	2:45	3:00
/4	9:49	4:16	3:19	3:20	4:30	4:33	4:10	3:30	3:30	3:41
/5	4:55	4:12	3:10	4:05	5:12	2:50	3:24	2:20	2:34	2:25
/6	6:52	3:47	3:59	4:17	8:05	3:45	5:37	3:10	3:05	3:23
Absalve/1	6:12	4:49	4:00	4:44	4:00	9.20	8:00	4:00	4:25	3:55
/2	7:10	6:19	5:00	6:05	4:35	9:20	7:55	4:10	4:54	5:10
/3	6:13	3:29	3:18	4:00	4:47	4:27	5:57	3:43	3:39	3:36
/4	6:39	3:55	4:15	3:46	6:38	4:48	4:00	4:24	3:30	3:20
/5	3:05	3:31	3:35	3:11	5:27	3:25	5:11	2:35	2:54	2:10
/6	6:07	4:02	3:59	4:30	5:42	4:30	6:02	3:26	3:33	3:58
	1:38:15	1:11:39	1:06:50	1:13:01	NC	NC	NC	1:04:30	1:02:30	1:01:37
No. Trials	15	18	18	18				18	18	18
$\bar{X}$	6:33	3:59	3:43	4:03				3:35	3:28	3:25

UNDERLINED MEANS ASSISTANCE TO THE DRIVER REQUIRED

Legend
(C) Closed hatch
(O) Open-hatch