ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

First Partial Report

On

PROJECT, AMRL No. 37 and NDRC No. SOS-11 - STUDY OF ERRORS IN FIELD ARTILLERY PRACTICE

INFORMATION COPY

Project AMRL No. 37 and NDRC No. SOS-11

18 September 1944

ARMORED MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

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FIRST PARTIAL REPORT ON STUDY OF ERRORS IN FIELD ARTILLERY PRACTICE

1. PROJECT: AMRL No. 37 and NDRC No. SOS-11 - Study of Errors in Field Artillery Practice. First Partial Report.

a. Authority: Ltr. AGF, 413.68 (R) (8 Apr 1944) GNRCT-10/78261 dated 8 April 1944.

b. Purpose: To make preliminary observations on the nature, source and magnitude of errors which occur in Field Artillery practice and to outline a plan for further study designed to determine: (1) the causes and relative frequency of errors from different sources; (2) the relative influence of errors from various sources upon effectiveness and density of artillery fire; (3) the degree of improvement in effectiveness of artillery fire which can be expected from proposed changes in instruments and procedures.

2. DISCUSSION:

Several points have emerged from the preliminary studies which are significant in further consideration of the problem:

a. The occurrence of errors in Field Artillery practice is generally recognized. Many of the errors are traceable to certain weaknesses in the system, weaknesses in the sense that no positive protection against errors is provided. Experienced Artillery officers emphasize the relatively greater frequency of errors among men who have not been highly trained. In normal peacetime training, full consideration is given to the sources of error and it is said that they are largely eliminated through repeated and prolonged training, together with selection of artillery personnel by trial. In this way, recognized opportunities for mistakes are overcome to a large extent. This method of elimination of errors breaks down in the more accelerated war-time training program, and the frequency of errors, therefore, assumes greater importance. As a general statement, it may be said that the present problem is one of minimizing opportunities for error so that fewer mistakes will be made despite limited training.

b. The preliminary observations indicated no clear-cut pattern of occurrence of errors at any particular point or points within the system. Errors have been observed wherever commands are formulated, transmitted or executed, and at every situation involving the setting and reading of instruments, making computations, etc. The 100 mil error, so commonly mentioned, is not unique. Others of lesser or greater magnitude occur with considerable frequency and for quite different reasons.

c. The occurrence of an error at any point in the system cannot always be regarded as an isolated event which can be attributed entirely to the operator or instrument at the point of occurrence. On the contrary, in a well-trained unit there appears to be some relation between the occurrence of errors and immediately preceding confusion of commands, incorrect transmission of data or departure from standard operating procedure. This interrelation of steps in the whole system is well recognized and constitutes a major reason for emphasis in training and practice upon close adherence to standard operating procedures.

d. While it would be desirable to eliminate all sources of error, it is recognized that this is difficult, if not impossible, of attainment. It is necessary, therefore, to evaluate the relative importance of each kind of error in accordance with a common and meaningful yardstick. Errors are of importance if they increase expenditure of ammunition, decrease the density and effectiveness of fire on a target, bring fire onto friendly troops or prevent the desired close artillery support to the infantry. A gross error, such as 100 ₥ in deflection or elevation, may be a source of danger to friendly troops, but in registration or adjustment it is frequently so obvious that it will be recognized and corrected with no great waste of ammunition or time. On the other hand, an error of small magnitude may go unrecognized and cause considerable loss of ammunition and time before its effect is eliminated. In this connection, it is recalled that throughout the process of adjusting fire, the observer must assume that the shifting of burst which he observes correctly follows his commands or transmitted data. If this is not the case, his technic of adjustment breaks down. In fire for effect, large errors are no more important than small errors if both miss the target. The influence of an error upon effectiveness of fire is not necessarily removed by correction before firing. Delay in execution of commands may increase the time to bring in the fire of one of the batteries and thus reduces the effectiveness against targets which require a given density of fire for accomplishment of mission. In such cases the magnitude of the potential error has no significance.

e. It is not anticipated that simplified procedures and improvements in instruments and aids will eliminate all errors. The proper training of men to insure concentration upon the job at hand is of primary importance and must remain so, even in the most ideal system.

3. CONCLUSIONS:

a. Errors occur at all points in Field Artillery practice where commands are formulated, transmitted or executed, data collected and recorded and computations made, and in every operation requiring setting and reading of instruments.

b. There is evidently no clear-cut, repeating pattern of errors which direct attention to a few particular sources. The frequency of errors decreases with increased training but the distribution with respect to source does not change to a marked degree.

c. Obvious sources of error are seen in the operation of certain instruments which can be largely eliminated by improved design. Others are caused by more obscure factors, requiring further investigation before they can be clearly defined and improvements effected.

4. RECOMMENDATIONS:

a. That every instrument employed in the conduct of Artillery fire be studied systematically with reference to its probable contribution to errors and improved instruments be designed to eliminate such sources of error.

b. That a critical job analysis be made of each major division of the operations involved in the conduct of Artillery fire, to provide more detailed information relative to the causes of error and to furnish the basis for development of methods of improvement.

c. That test facilities, including means for complete recording of all operations in the conduct of fire, be established and employed (1) for measuring the relative influence of errors from different sources upon the overall effectiveness of Artillery fire and (2) to determine the degree of improvement in effectiveness of fire which can be expected from improved instruments or proposed changes in procedure.

5. ACKNOWLEDGEMENT: The data in Tables 1, 2 and 6 and other specific data presented in the Appendix were provided by the Field Artillery School, Fort Sill.

6. CONCURRENCE: The present report, conclusions and recommendations represent the joint work of the AMRL and the staff of NDRC Project SOS-11. The report is concurred in by Dr. John P. Nafe, Director, Project SOS-11.

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2 Incls.
#1 - Appendix
#2 - Tables 1 thru 7

APPENDIX

1. For purpose of defining the problem of errors in Field Artillery practice and in order to formulate a definitive program of investigations and development of means for the elimination or minimizing of errors, preliminary field observations were made at the Field Artillery Replacement Training Center, and 100th Division at Fort Bragg, followed by further investigation in the Field Artillery School at Fort Sill, and discussion of the problem with the School staff. Owing to the limited period of observation and to the fact that little quantitative data were collected, the present statement of the problem and the proposed plan for future study are not necessarily complete. Basically, however, it is believed that the problem has been fairly well defined and no major change in plan of study is anticipated.

2. Summary of Observations and Data:

a. Survey: Errors in survey are reported in: (1) measuring angles, (2) measuring distances, (3) computations of coordinates. The error most frequently reported to us was in measurement of distance - the so-called "dropping a tape length". This error, which is not uncommon in civilian, as well as military, surveying results from no instrument deficiency, but, rather, from lack of sufficient concentration upon the task at hand. It is minimized, but not eliminated, by the use of tally pins to keep account of the number of tape lengths.

Errors also occur in measuring angles with the aiming circle (see discussion under "Instruments" and Table 6) and in making computations. The recent development of the military slide rule for the calculation of coordinates and solution of triangles has undoubtedly reduced the frequency of errors in these operations.

b. At the Battery. Errors in use of the aiming circle occur in laying the battery as well as in surveying. No 100 ₥ errors in this operation were observed by us but several of recent occurrence were reported and it was evident from interviews that it is a recognized source of error. In one instance an observed error of 200 ₥ resulted from incorrect command. The battery was laid on az. 4190 and the command was suddenly changed to 4090. The corrective order to the battery was R 100. The resulting 200 ₥ error was discovered and corrected before firing. An analysis of errors at the battery among school troops at Field Artillery School, Fort Sill, revealed that 20% of the errors were made by the executive (see Table 1); presumably, these consisted mainly of errors in laying. The remaining 80% of errors in Table 1 occurred at the guns and arose primarily from misuse of the gun-laying instruments, failures in communications or improper execution of commands. Deficiencies in instruments which account for some of these errors are discussed in a later section. A similar analysis of errors recorded at the battery in firing 95 problems at Fort Sill is given in Table 2. This table includes records of magnitude as well as source of errors and illustrates the

wide range in magnitude which may be expected. It is interesting to note that fourteen out of the 56 errors recorded were 100 ₥ in magnitude. Observed errors during firing by a battery from a well-trained battalion are recorded for 231 records in Table 3. The range in magnitude of errors in deflection and elevation observed among trainees, shown in Table 4, is similar to that recorded for the School Troops in Table 2.

c. Procedures at OP.

Observations of procedures at the OP were of limited significance owing to the fact that student officers with little previous experience were conducting fire in each case. The following do, however, illustrate the importance of following standard operative procedures and sending clear instructions.

(1) Observer wanted a shift of R 123 but gave an order for L 123; error = 246 ₥.

(2) Observer called 200 R, meaning to say 300 R, he followed this by "correction" and 300 R. Both commands were executed at the guns, making a total shift of 500 yards.

(3) An observer sensed a round as short and then ordered down 100 yards.

(4) Indecision on the part of the observer caused errors. For example, an order for a small deflection was changed to a larger shift. Both were summated at the guns.

(5) An order of L 110 was received at the guns, followed by R 10. A check was requested by one of the gunners and the reply was "Command was L 100". The gunner interpreted this as rescinding the last order of R 10, thus making his total deflection L 210 or an error of 110 ₥. This is an illustration of errors at the gun being caused by confusion higher in the chain of command.

d. Transmission of Commands and Data

Errors were observed resulting from:

(1) Similarity of sounds: R 195 understood as R 155
El 238 understood as El 288.

(2) Confusion from 4 digit numbers: 2988 understood as 2998;
3041 understood as 341.

(3) Misunderstanding: Obs. to T.O. 400 R; message transmitted 100 R.
Deflection R 30 understood as R 20.
T.O. to Exec. El 285; Exec. to btry. El 185.

In a recent study by the Communications Department, FA School, an average of three (3) errors in communication occurred per mission fired. Two-thirds of these were discovered and corrected before firing but the delay which they introduced resulted in decreased density of battalion fire on the target.

e. Procedures at FDC.

The operations at FDC are of such a nature and the work is so concentrated that errors are bound to occur in transmission of messages or data, making computations, reading instruments, etc. Recognition of the opportunities for error has resulted in the recent re-design of the range-deflection fan and improvement of GFT scales and minipulation. Approximately one (1) error per mission occurred at FDC in a recent study by the Communications Department, FA School.

f. Failure to execute commands correctly and use of improper technics.

Most common error was in direction of deflection shift of guns, left instead of right and vice versa. The frequency of occurrence is evidently great, especially in trainees. Other examples included failure to complete new elevation adjustment - quadrant set properly but gun not leveled; setting off deflection shift properly on panoramic sight but then coming back onto the aiming stakes by rotating the sight and leaving the gun in its original alignment. Use of site adjustment knot instead of elevation was noted once. Use of the wrong aiming stakes was noted frequently among trainees. Certain trained units employed different identification colors on stakes or other means of avoiding this mistake. In one instance when gun was known to be out of alignment with aiming stakes the gunner used the wrong far stake.

g. Instrumental Errors.

The 100 ₥ error was noted frequently in deflection settings and from time to time in elevation. Errors resulting from confusion in selection of proper major graduation on micrometer scale were also observed; for example, setting El 207 instead of El 212.

All instruments employed in the conduct of Field Artillery fire are subject to error in use, varying in this respect with their complexity. Even as simple a process as measuring distances in survey by taping is accompanied by the dropping of a tape length. Of greater complexity are the sources of error in the aiming circle, panoramic sights, gunner's quadrant, etc. These instruments have a number of features which complicate their setting and reading, most of which are capable of improvement by redesign. The M-12 panoramic sight may be considered as a case in point. In order to obtain a complete azimuth reading of four digits, it is necessary to read two of the figures from one scale and two from another, displaced from each other in a direction opposite to the position of the digits in the whole number. This is contrary to common

experience in reading and leads to confusion. Reading of the total angle from two displaced scales accounts for the well-known 100 ⋔ error, which occurs primarily in reading angles just below or above even hundreds values. In such cases the index on the coarse scale is close to a hundreds line to which it is related only if the micrometer reading is just above zero. Unless the micrometer scale is first examined, therefore, the wrong coarse scale value may be taken. Further confusion arises from the fact that the coarse scale 100 ⋔ increment lines are all of equal length and are numbered only at 400 ⋔ intervals. The interpolation thus required in reading angles midway in value between numbered points adds to the probability of the 100 ⋔ error.

The pattern of errors which are likely to occur in reading deflections with the M12 sight are illustrated in Table 5. These records were obtained in a series of "dry runs", employing two groups of School Troops at Fort Sill, assigned as experienced and inexperienced men. The series of twenty angles to be measured were selected in advance to include a preponderance of values in the danger zones, that is, near even 100 ⋔ values. The findings are significant. Among the experienced men there were sixteen 100 ⋔ errors out of 340 readings, all of which occurred in reading angles near an even hundreds value. Of the eight errors in reading angles just below an even hundreds value, seven were recorded for angles which were midway in value between numbered markings on the coarse scale of the instrument (Group a under I in the table); for example, 1396 ⋔ lies half-way between the numbered scale values 12 and 16. Similarly, for the three angles just above even hundred mil values, six out of the eight errors occurred in reading angle 1011, also midway between numbered markings on the coarse scale. The frequency of total errors was approximately four times greater among inexperienced men as compared with the experienced men but the pattern of errors was essentially similar for the two groups. Particular attention is called to the confusion in reading angle 1011 ⋔ (Six -100 ⋔ errors out of 17 readings by experienced men) which suggests that the sudden jump from 3 digits to 4 digits added to the uncertainty.

Another source of error in the M12 panoramic sight arises from the limited capacity and function of the gunner's aid. Its inadequacies are best demonstrated by the fact that no general agreement exists among artillery officers as to the proper manner of use of the aid. In one instance trainees were instructed not to use it because it was felt that it actually caused errors. Among other units, different methods of use were noted but in no case did we see it employed in the manner recommended in Ordnance manuals. The concept of the gunner's aid is well established, and it should be designed to serve completely and obviously for the intended purpose, namely; the minimizing of required mental calculations on the part of the gunner in executing commands.

A somewhat similar study of errors to that made on the M12 panoramic sight in measurement of angles by means of the aiming circle was recently carried out by the FA School. The study employed 110 student officers as test subjects. Six angles were measured along a closed traverse, the angles varying in size as indicated in Table 6. Three of the angles were close to even hundreds, viz: 795.0, 1193.7 and 1198.7. The same two instruments* were employed by all

* Plateau scale removed.

subjects. It was possible to account for most of the incorrect readings either as instrumental errors or mistakes as indicated in Table 6. For pusposes of analysis, most of the errors within ± 3 ⌀ have been catalogued as instrumental, i.e., within the limitations of accuracy of setting of the instrument by operators not highly skilled in its use. The remaining errors, catalogued as mistakes have been distributed into four categories as to cause from a study of the magnitude and sign of the error in each case. The first of these causes is reading the wrong side of the adjacent major graduation. For example, for angle 1199 there were 12 readings of 1201 which are interpreted as mistakes resulting from reading the 12 hundred mil value on the coarse scale and reading the micrometer as 1 rather than 99. Similarly, for angle 836 there were 9 readings of 834. Larger errors were apparently caused by reading the micrometer to the nearest major graduation mark; for example, reading 790 instead of 795, 840 instead of 836, etc. There were 8 cases where angle 836 was recorded as 853. It is possible that the angle was read as 835 and the figures transposed in recording; they have been so classified in the table. A total of fourteen 100 ⌀ errors occurred, all for angles close to an even hundreds value. Nine out of the fourteen were recorded for angle 795, thus accounting for over 8% of the readings of this angle. The summary of results at the bottom of the table shows that only one-half of the readings were correct to the nearest mil and 80% were correct to within ± 1 mil. Fifteen percent of the recorded values were evident misreadings, which may be attributed to weaknesses in scale design and displacement of the two scales.

A partial list of sources of error within the system is given in Table 7. It is recognized that nothing new was obtained from these observations of summary of reported errors. They merely corroborate common knowledge among Field Artillery officers. Awareness of the universality and magnitude of the problem and necessity for constant effort toward the elimination of errors was evident in all discussions. The complexity of the problem indicates that no ready general solution can be expected. There are certain obvious sources of error in instruments which appear capable of immediate improvement but others of more subtle character, related particularly to wording and transmission of commands, order of procedures, computations, etc., require more extensive study before possible improvements can be developed. Regardless of the number of improvements in procedure or instruments which may be affected, it is clearly understood that the conduct of Field Artillery fire is and must always remain primarily dependent upon the personnel for success. There can be no substitute for adequate training, continuous adherence to SOP and complete concentration upon the task at hand while performing duties within the system. The question may properly be asked, however, to what extent procedures can be improved and instruments simplified so as to reduce opportunities for error when there is any departure from the ideal functioning of the system. The immediate plan, therefore, is to initiate studies designed to bring out sources of error which are capable of elimination or reduction in frequency of occurrence.

4. Plan of Future Study.

For purposes of further detailed study of the problem, the following plan of investigation is indicated:

a. Improvement in instruments. The preliminary observations clearly point to the need for improvement in instruments, especially in design of scales for more certain reading. Immediate steps are being taken to effect such improvements, with two lines of development in mind; First, changes in design which will not affect the basic construction of the instrument and can be applied quickly to existing instruments; second, more complete redesign with a view to further improvement in function, but requiring changes in construction which can only be employed in later production.

b. Detailed job analyses - This phase of the study contemplates a critical examination of every procedure and job within the system with particular reference to the opportunities for error which exist in the performance of the required operation. The work will consist primarily in regular observation and study of errors in independent "dry-runs" of each operation or major group of operations taken separately. The purpose will be to provide a detailed background of information on the nature and cause of errors that do occur in each instance. The studies will be so designed as to give quantitative measurements, so far as possible, of the importance of such errors in relation to the overall effectiveness of artillery fire.

c. Critical study of operation of entire system. By means of facilities for complete recording of all operations in conduct of fire, the functioning of the entire system will be studied during actual firing. From the data thus collected, full information on nature, magnitude and sources of errors will be determined under various conditions of operation. It will also be possible to measure the benefits from certain proposed improvements in instruments and operations in quantitative terms of relative effectiveness of fire.

TABLE 1

Distribution of Errors Observed at Battery Position
F. A. School, School Troops, Ft. Sill, During a Two Year Period

	NUMBER	PERCENT
TOTAL ERRORS	1765	
1. Errors made by Executive	347	20.2
2. Errors at the Guns:		
(a) in Deflection	1084	61.7
(b) in Range	236	12.5
(c) in Distribution	98	5.3

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TABLE 2

Summary of Type and Magnitude of Errors Made During Ninety-five Problems -- F.A. School, School Troops

TOTAL ERRORS 56

1. ERRORS MADE AT GUNS

A. In Deflection
Number: 24 (43%)
Magnitude in mils: 3-12-13-25-40-74-84-100(8)*-140-150-160-200(2)-240-280-300-405

B. In Elevation
Number: 10 (18%)
Magnitude in mils: 10-20(2)-30-53-75-98-100(3)

C. In Site
Number: 3 (5½%)
Magnitude in mils: 7-30(2)

D. In Range
Firing Wrong Charge: 4 (7%)
Wrong Fuse Setting (Suggested): 7 (12½%)
Magnitude - 300 to 2500 yds.

2. ERRORS MADE BY EXECUTIVE IN LAYING BATTERY

Number: 8 (14%)

Magnitude in mils: 37-57-100(3)-200-203-403

*Numbers in ( ) indicate number of times that error occurred.

Incl. #2

TABLE 3

Observed Errors Made at Battery and O.P.
Well-trained Battalion
Fort Bragg

	NUMBER
Total Rounds Fired	231
Total Problems Fired	16
Problems having errors	10
Largest No. of Errors in One Problem	4
TOTAL ERRORS OBSERVED	15
Type of Errors at Guns	
(a) Deflection	5
(b) Elevation	3
(c) Site	1
(d) Fuse Setting	4
(e) Recorders	2
Errors due to Confusion at O.P.	4

Incl. #2

TABLE 4

Kind and Magnitude of the Errors Observed at Guns During Service Practices of FARTC Trainee Groups Fort Bragg

In Deflection (mils)
1, 2, 3, 4, 5, 6, 9, 10, 15, 18, 20, 22, 28, 30, 32, 40, 53, 60, 64, 100, 130, 180, 286, 400, 500
In Elevation (mils)
5, 16, 18, 20, 36, 40, 60, 80, 100

Incl. #2

TABLE 5

Errors in Measurements of Deflections with Telescope, Panoramic, M12

Angle, ₥	Number of Errors			
	Experienced Men (17)		Inexperienced Men (20)	
	100 ₥	Other	100 ₥	Other
	I. Angles Just Below Even 100 ₥ Value			
a. 194	1	-	5	1
287	1	1	7	2
687	1	-	7	-
1097	-	-	8	1
1396	3	-	9	-
1885	1	-	3	1
b. 389	-	-	4	1
393	-	-	6	1
498	1	-	2	1
791	-	-	3	-
890	-	-	3	1
2894	-	-	2	-
Totals	a. - 7(3.4%) b. - 1(0.5%)	a. - 1(0.5%) b. - 0	a. - 39(16.2%) b. - 20(8.3%)	a. - 5(2.1%) b. - 4(1.7%)
	II. Angles Just Above Even 100 ₥ Value			
307	1	-	2	-
906	1	2	-	5
1011	6	-	5	1
Totals	8(15.7%	2(3.9%)	7(11.7%)	6(10.0%)
	III. Intermediate Angles			
265	-	1	4	2
548	-	-	3	-
841	-	-	-	-
1262	-	-	-	-
2822	-	1	-	-
Totals	0	2(2.3%)	7(7.0%)	2(2.0%)

Incl. #2

TABLE 6

Summary of Tests on Angle Measurements by Aiming Circle
110 Subjects

F.A. School - Fort Sill

	Measured Angle - Mil						
By Transit	795.0	1193.7	1198.7	835.8	1165.6	1211.4	Totals
Most Freq. by A.C.	795	1194	1199	836	1165	1211	
I. No. Correct Meas.	47	70	47	54	53	54	325
II. No. Instr. Errors							
± 1 mil	39	24	34	29	27	45	198
± 2 mil	9	-	-	-	-	3	12
± 3 mil	-	4	10	1	2	1	18
Total	48	28	44	30	29	49	228
III. MISTAKES							
Read wrong side maj. grad.	-	4	12	9	8	-	33
Read near maj. grad.	2	5	1	7	7	-	22
Transposition of Figures	-	-	-	8	-	-	8
100 Mil Plus	9	1	4	-	-	-	14
Record. reverse angle	-	-	2	-	-	2	4
No obvious explanation*	4	2	-	2	8	5	21
Total	15	12	19	26	23	7	102

% Correct = 49.5; % Instr. Errors up to ±3 mil = 34.8; % Mistakes = 15.7

*Ranging in magnitude from 4 to 50 mils

Incl. #2

TABLE VII

PARTIAL LIST OF SOURCES OF ERROR IN ARTILLERY PRACTICE

I. In Survey.

a. Resulting from misreading or improper manipulation of aiming circle or transit.

b. Errors in measuring distance.

(1) Dropping tape length.
(2) Reading tape from wrong end.
(3) Confusion of feet and yards.

c. Errors in computations.

II. At Battery.

a. Resulting from misreading or improper operation of instruments.

(1) Aiming circle.
(2) Panoramic sight.
(3) Quadrant - gunner's and mounted.
(4) Fuse-setting scale.
(5) Inadequate illumination of instruments.

b. Resulting from improper technics.

(1) Deflection shift in wrong direction.
(2) Failure to level bubbles at proper time.
(3) Use of wrong aiming stakes.
(4) Improper powder charge.
(5) Departing from SOP (Failure to call "The Command was", etc.)

c. Resulting from errors of communications - lack of attention - not concentrating on task at hand.

III. At Fire Direction Center.

a. Resulting from misreading or improper operation of instruments.

(1) Using incorrect scale for map.
(2) Range - deflection fan and protractor.
(3) Graphical firing table.

Incl. #2

b. Resulting from improper technics.

(1) Errors in computations.
(2) Errors in graphical plotting and analysis.

c. Resulting from errors of communications - lack of attention and not concentrating on task at hand.

IV. At Observation Post.

a. Misreading observation instruments.

b. Failure to sense properly in regard to GT and OT lines.

c. Departure from SOP.

d. Errors in communication.

V. Communication.

a. Too many individuals involved in transmission of message.

b. Not using clear enunciation of words.

c. Failure to use proper pronunciation to distinguish between words with similar sounds.

d. Failure to follow SOP.

e. Lack of concentration on task at hand.

VI. Personnel.

a. Inadequate period of training.

b. Inadequate mathematical capacities.

c. Limited visual capacities - day and night.

d. Hearing - speech.

e. Fatigue.

f. Environmental factors - noise, illumination, mental stress.

g. Lack of attention.