

Recording and Abstracting Procedures

RECORDING HORIZONTAL DIRECTIONS

Recording horizontal directions will be the same for all orders of accuracy. Horizontal directions will be recorded in *DA Form 4253, Horizontal Direction or Angle Book*, authorized single sheet recording forms, or appropriate media when operating automated integrated survey instruments (AISI). In all cases, complete documentation will be performed in the field. Each time an SCP is occupied, the following will be recorded:

- 1 **Instrument make, model, and serial number.**
- 2 **Instrument operator's name.**
- 3 **Recorder's name.**
- 4 **Weather description** – three words describing –
 - ŽTemperature.
 - ŽGeneral atmospheric condition.
 - ŽWind.
- 5 **Complete designation of the station occupied**–
 - ŽFull station name.
 - ŽYear the monument was installed.
 - ŽName of agency on the disk.

Each station observed will, when first listed on a page or form, be identified by full station name, year monumented, and name of agency on the disk. If an instrument, signal, or target is set eccentric to a station (not plumbed directly over the station mark), that item will be sketched on the recording form, showing –

- 1 **Distance of the item from the station.**
- 2 **Relative directions of the item to –**
 - ŽStation is set eccentric from.
 - ŽFirst distant station in a clockwise direction.
 - ŽIncluded angle.

Where intersection stations are observed, the exact part of the object sighted upon must be recorded and shown in a sketch.

Numbers and letters should be approximately half the height between lines. The recording should be centered in the block and on the bottom line of the block. All figures must be neat and legible. There will be no erasures or obscuring of the original figures. Original numbers may be crossed out using a single diagonal line through the numbers. The corrected numbers will be written above the original entry. The person making the correction will place his initials above and to the right of the original entry and within the block. The person making the correction will explain the reason for the correction in the Remarks

column when he makes the correction. No position will be voided or rejected on any recording media, except in the case of bumping the instrument or stand, causing the instrument to become unlevel. If the instrument is observed to be unlevel, make a note on the recording media in the Remarks column stating that the instrument was not level, and why. All recordings will be done with a dark reproducible ink, preferably black or blue-black. Directions in degrees, minutes, and seconds will be entered in the Remarks column. A note will be entered in the Remarks column for the first position of each set, describing the general condition: “No eccentricity of instrument or target,” “Eccentric target shown to all stations.” or other appropriate entry.

Every computation on each page or sheet will be checked by the observer. The observer will verify the computation with a light, visible tick mark to the upper right of the computed numbers, or will correct the numbers (as described above). The observer will confirm that he has checked all computed numbers on the page by placing his initials at the bottom right corner of the page.

On the appropriate page in the front of the recording book, an index will be made of the stations from which observations were made and recorded within the book. An index will also be required for all other recording media, listing where to locate observations from any occupied SCP.

Refer to the appropriate illustration for the following types of observations:

- 1 **Traverse** (using 1-second theodolite) (includes determining horizon closure and corrected station and explement angles for third-order accuracy projects) – Figure 6-1.
- 2 **Triangulation** (using 0.2-second theodolite) – Figure 6-2.
- 3 **Zenith distance** (using 1-second theodolite) – Figure 6-3.
- 4 **Vertical angle** (using 0.2-second theodolite) – Figure 6-4.
- 5 **Side shot** (used for airfield obstruction positioning and reporting) – Figure 6-5.
- 6 **Astronomic azimuth** – Figures 6-6a and 6-6b.
- 7 **Two-point intersection** – Figure 6-7.
- 8 **Plane table** – Figure 6-8.

STATION LEWIS (30TH ENGR BN) 68 DATE 2 JUNE 19 88
 INSTRUMENTMAN SFC J DOE INSTRUMENT WILD T-2 # 1012
 RECORDER SFC K. 2 MOE WEATHER COLD CLEAR + CALM

POS. REP.	OBJECT OBSERVED	CHRON TIME			STOP WATCH	TEL D/R	CIRCLE	
		H	M	S				
1	KING 30 TH ENGR BN 68					D	00	00
						R	180	00
	ET-1 USC + 65 68					D	325	10
						R	145	10
2	KING 30 TH ENGR BN 68					R	210	02
						D	30	02
	ET-1 USC + 65 68					R	175	12
						D	355	12
1	ET-1 USC + 65 68					D	00	00
						R	180	00
	KING 30 TH ENGR BN 68					D	34	51
						R	214	51
2	ET-1 USC + 65 68					R	210	02
						D	30	02
	KING 30 TH ENGR BN 68					R	244	52
						D	64	52

MICRO. VERN. 1ST / A(°)	MEAN D/R	DIR. ANG	REMARKS	LEVELS	
				W	E
52					
58	55.0	00.0			
31			STA		
35	33.0	38.0	325° 09' 38.0		
32					
28	30.0	00.0			
12			STA		
07	09.5	34.5	325° 09' 34.5		
			MN STA 325° 09' 38.8		
48					
53	50.5	00.0			
15					
19	17.0	26.5	EXP 34° 50' 26.5		
27					
26	26.5	00.0			
56					
48	52.0	25.5	EXP 34° 50' 25.5		
			MN EXP 34° 50' 26.0		
			MN STA 325° 09' 38.8		
			HC 360 00 04.8		
			CORA -04.8 -2.4 + -2.4		
			CORA STA 325° 09' 38.4		

DA FORM 4253
 1 JUN 74
 (Blue)

Figure 6-1. Recording procedures for horizontal directions using 1-second theodolite

STATION		LEWIS 30 TH ENGR BN 68		DATE		JUNE 19 88	
POS.	OBJECT OBSERVED	CHRON TIME		STOP WATCH	TEL D/R	CIRCLE	
REP.		H	M	S			
1	Δ JAMES usc+gs 68	01	18		D	00 00	
					R	180 00	
	Δ WILLIS usc+gs 68				D	67 14	
					R	247 14	
	Δ KING 30 TH ENGR BN 68				D	123 39	
					R	303 39	
2	JAMES usc+gs 68				R	191 00	
					D	11 00	
	WILLIS usc+gs 68				R	258 15	
					D	78 15	
	KING 30 TH ENGR BN 68				R	314 39	
					D	134 39	
THE REMAINING POSITIONS ARE SIMILAR TO THESE, EXCEPT THAT THE PLATE IS ADVANCED TO THE PROPER INCREMENT.							

Figure 6-2. Recording procedures for horizontal directions using 2-second theodolite

For use of this form, see FM 5-232, the proponent agency is TRADOC.

[illegible]

DA Form 5817-R, AUG 89

Figure 6-3. Recording procedures for observing zenith distances using 1-second theodolite

Zenith Distance/Vertical Angle

For use of this form, see FM 5-232, the proponent agency is TRADOC.

STATION LEWIS (USC + 65) 29

DATE PM 14 OCT 19 60B

INSTRUMENTMAN SFC J. DOE
RECORDER SP4 W. ROE

INSTRUMENT WILD T-3 # 1852
WEATHER CALM COOL + CLEAR

[illegible]

DA Form 5817-R, AUG 89

Figure 6-4 Recording procedures for vertical angle using 0.2-second theodolite

STATION LAGUNA-A SIDE SHOT DATE 8 MAR 19 86 INSTRUMENTMAN SPC HOWSIE INSTRUMENT WILD T-2 #51735
 RECORDER SPC POTTS WEATHER WARM, BREEZY, CLOUDY

POS. REP.	OBJECT OBSERVED	CHRON TIME			STOP WATCH	TEL D/R	CIRCLE	MICRO. 1ST / A(°)	VERN. 20 / B(°)	MEAN D / R	DIR / ANG	REMARKS	LEVELS	
		H	M	S									W	E
1	COMPASS ROSE									12.0				
	BERM													
										16.0	STA 305	10 04.0		
2	COMPASS ROSE									20.0				
	BERM													
										24.0	STA 305	10 04.0		
											MN STA 305	10 04.0		
1	BERM									22.5				
	COMPASS ROSE									07.5	EXP 54	49 45.0		
2	BERM									20.0				
	COMPASS ROSE									10.5	EXP 54	49 50.5		
											MN	EXP 54	49 47.8	
											MN	STA 305	10 04.0	
											HC	359	59 51.8	
											CORR	08.2	04.1	04.1
											CORR	STA 305	10 08.1	

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Figure 6-5. Recording procedures for side shot

[illegible]

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Figure 6-6b. Recording procedures for astronomic azimuth using 0.2-second theodolite

STATION HANCHEY (30TH ENBR BN) SI INSTRUMENTMAN SP4 FISH INSTRUMENT WILD T-2 #72071
 RECORDER _____ WEATHER CLEAR CALM COOL

DATE 6 MAY 1988

POS REP	OBJECT OBSERVED	CHRON TIME			STOP WATCH	TEL D/R	CIRCLE	
		H	M	S				
1	HANCHEY AZ MK (30TH ENBR BN) SI					D	00	00
						R	180	00
	NDB					D	47	21
						R	277	21
2	HANCHEY AZ MK (30TH ENBR BN) SI					R	270	00
						D	90	00
	NDB					R	07	21
						D	187	21
1	NDB					D	00	00
						R	180	00
	HANCHEY AZ MK (30TH ENBR BN) SI					D	262	39
						R	82	39
2	NDB					R	270	00
						D	90	00
	HANCHEY AZ MK (30TH ENBR BN) SI					R	172	39
						D	352	39

MICRO./VERN. 1ST/AC' 2D/B'	MEAN	MEAN D/R	DIR/ ANG	REMARKS	LEVELS	
					W	E
30						
31		30.5		POINT OBSERVED		
03						
02		02.5				
			STAY	47° 20' 32.0		
31						
29		30.0				
04						
02		03.0	STAY	47° 20' 33.0		
			MN STAY	47° 20' 32.5		
31						
30		30.5				
57						
58		57.5	EXPLA	262° 39' 27.0		
32						
31		31.5				
59						
58		58.5	EXPLA	262° 39' 27.0		
			MN EXPLA	262° 39' 27.0		
			MN STAY	47° 20' 32.5		
			H° R 4005	359° 59' 59.5		
			ERRR	-00.5		
			ERRR	+00.2 +00.3		
			COXR STAY	47° 20' 32.7		

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Figure 6-7. Recording procedures for airfield two-point intersection

DA Form 5818-R, AUG 89

Figure 6-8. Recording procedures for plane table

ABSTRACTING OF HORIZONTAL DIRECTIONS

Second-order horizontal observation specifications require that an abstract of horizontal directions be compiled for every station at which horizontal directions have been observed. *DA Form 1916, Abstract of Horizontal Directions*, will be completed before leaving the SCP. (Third-order horizontal observations require the determination of horizon closure, corrected station angle, and corrected explement angle on the recording form. This will be accomplished prior to leaving the SCP.) Readings will be entered opposite the proper circle position, as indicated in the field notes. The degrees and minutes for each direction are entered only once, at the top of each column, and the seconds are entered for each circle position (Figure 6-9). The following is a summary of requirements when abstracting and rejecting horizontal directions.

Record all positions observed onto *DA Form 1916*. If two or more observations have been made for the same circle setting (position), list all the observations in the same box and determine the mean for that position.

Examine the list of the form. For all positions which appear to vary greatly from the apparent mean of all the positions, check the computations in the field recording book or recording media. Be alert for a change in the minutes of the computed directions (angles) in the field data. Reject any positions which vary widely from the mean and reobserve the positions. Values that are rejected will be enclosed in parentheses, and followed by "R₀." "R₀" indicates that the value was rejected by observation.

Determine (compute) a mean of the observed positions. The mean value of a direction will be rounded off to the nearest 0.01 second if a T-3 theodolite was used for observations. The mean value of a direction will be rounded off to the nearest 0.1 second if a 1-second instrument was used for observations. Reject all observations which differ from the mean by more than the rejection limit (from *Standards and Specifications for Geodetic Control Networks*). Enclose any rejected observations with parentheses, and annotate with "R1." "R1" indicates that the value was rejected using the first mean value. The rejection limit will be applied to each observation with the same amount of accuracy as when the mean was determined (0.01 second for 1/10-second instruments, 0.1 second for 1-second instruments).

Reobserve any rejected positions and redetermine anew mean. Reapply the rejection limit. Any positions still exceeding the rejection limit will be enclosed in parentheses and annotated with "R2." "R2" indicates that the value was rejected using the second mean

value. Ensure that sufficient positions remain acceptable (from *Standards and Specifications for Geodetic Control Networks*).

No value (reading) should be rejected if it is within the rejection limits, unless it was rejected at the time of observation. If a value was rejected at time of observation, check the field notes for the observer's reason for rejection.

Once a value is rejected, it cannot be used again.

If one of two or more readings on a position is outside the rejection limits, do not use the mean of the readings. Use only the reading which is within the rejection limits.

If two readings are outside the rejection limits (one high, the other low, and the mean is within the limits), the readings must be rejected.

If there is a progressive change in the values of the positions of a direction, or if the mean of the first half of the positions differs appreciably from the mean of the last half of the positions, attempt to observe another complete set of positions before leaving the SCP.

If repeat positions are observed at any circle setting during the same occupation of a station, combine the result of each additional observation with that of the original circle position. If, on second-order Class I triangulation, 12 or more additional positions are observed, they should be meaned separately and combined by sets.

On second-order Class I triangulation, two or more sets of 12 or more positions must be given equal weight, regardless of whether they are observed on the same or different nights. When two sets of 12 or more positions differ by more than 1 second, the set which best closes the triangle(s) is retained and the other set is rejected. In the case of three sets, sometimes two sets which agree with each other must be rejected and the third retained. Usually, the set or sets retained are those which are observed under the least harmful conditions of horizontal refraction. When there are more than two sets, any set which falls within 0.5 second of the individual or mean value which best satisfies the triangle(s) should also be meaned with that value.

If it appears that the initial is causing a large number of rejections, the observations can be listed by positions and directions on the abstract form, with some other station as the zero initial. In this case, the angle between the new initial and the original initial should be added to the listed circle settings to obtain the correct values to use when reobserving rejections, unless a complete new set of observations is to be made with anew initial. (See Table 6-1, pages 6-14 and 6-15.)

ABSTRACT OF HORIZONTAL DIRECTIONS										
For use of this form, see TM 5-237; the proponent agency is TRADOC.										
LOCATION MISSOURI			ORGANIZATION 99th ENG DET (Survey)				STATION LAKE (USGS) 1932			
OBSERVER SGT SMITH			DATE 2 APRIL 1989				INST. (TYPE) (NO.) WILD T-2 #28234			
POSITION NO.	STATIONS OBSERVED									
	BROOK (USGS) 1956	BASS (USGS) 1972	TROUT (DMA) 1989							
	(Initial) 0° 00'	47 46	91 34							
1	0 00	21.5	48.0							
2	0 00	22.0	46.5 (42.0) R							
3	0 00	22.0	46.5							
4	0 00	21.0	46.5							
5	0 00	21.5	46.0							
6	0 00	22.5 (36.0) R	48.5							
7	0 00	21.0	48.5							
8	0 00	21.5	48.5							
9	0 00	22.0	46.0							
10	0 00	21.5	48.5							
11	0 00	22.0	46.5							
12	0 00	21.5	49.5							
13	0 00									
14	0 00									
15	0 00									
16	0 00									
Sum,		260.0	569.5 (565.0) R							
Mean,		21.7	47.5 (47.1) R							
COMPUTED BY SFC JONES			DATE 2 APR 89			CHECKED BY SGT W D Smith			DATE 2 APR 89	

DA FORM 1916

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Figure 6-9. Abstracting horizontal directions

Table 6-1. Circle settings

Two positions of circle				10-minute micrometer drum					
1				0°	00'	10"			
2				90	05	40			
Four positions of circle				5-minute micrometer drum			Circle	Wild T-3*	Micrometer
1	0°	00'	40"	0°	00'	10"	0°	00'	15"
2	45	01	50	45	02	40	45	02	45
3	90	03	10	90	05	10	90	04	15
4	135	04	20	135	07	40	135	20	45
Six positions of circle									
1	0°	00'	10"	0°	00'	10"	0°	00'	15"
2	30	01	50	30	01	50	30	02	35
3	60	03	30	60	03	30	60	00	50
4	90	00	10	90	05	10	90	04	15
5	120	01	50	120	06	50	120	00	35
6	150	03	30	150	08	30	150	20	50
Eight positions of circle									
1	0°	00'	40"	0°	00'	10"	0°	00'	10"
2	22	01	50	22	01	25	22	00	25
3	45	03	10	45	02	40	45	02	35
4	67	04	20	67	03	55	67	00	50
5	90	00	40	90	05	10	90	04	10
6	112	01	50	112	06	25	112	00	25
7	135	03	10	135	07	40	135	20	35
8	157	04	20	157	08	55	157	00	50
Twelve positions of circle									
1	0°	00'	40"	0°	00'	10"	0°	00'	10"
2	15	01	50	15	01	50	15	00	25
3	30	03	10	30	03	30	30	02	35
4	45	04	20	45	05	10	45	00	50
5	60	00	40	60	06	50	60	00	10
6	75	01	50	75	08	30	75	00	25
7	90	03	10	90	00	10	90	04	35
8	105	04	20	105	01	50	105	00	50
9	120	00	40	120	03	30	120	00	10
10	135	01	50	135	05	10	135	00	25
11	150	03	10	150	06	50	150	20	35
12	165	04	20	165	08	30	165	00	50
Sixteen positions of circle									
1	0°	00'	40"	0°	00'	10"	0°	00'	10"
2	11	01	50	11	01	25	11	00	25
3	22	03	10	22	02	40	22	00	35
4	33	04	20	33	03	55	33	00	50
5	45	00	40	45	05	10	45	02	10
6	56	01	50	56	06	25	56	00	25
7	67	03	10	67	07	40	67	00	35
8	78	04	20	78	08	55	78	00	50
9	90	00	40	90	00	10	90	04	10
10	101	01	50	101	01	25	101	00	25
11	112	03	10	112	02	40	112	00	35
12	123	04	20	123	03	55	123	00	50
13	135	00	40	135	05	10	135	02	10
14	146	01	50	146	06	25	146	00	25
15	157	03	10	157	07	40	157	00	35
16	168	04	20	168	08	55	168	00	50

Table 6-1. Circle settings (continued)

Sets	Instrument** 10" setting			Instrument*** 20" setting			Instrument*** 30" setting		
	0°	00'	00"	0°	00'	00"	0°	00'	00"
1	90	05	30	90	10	20	90	10	30
2									
1	0	00	00	0	00	00	0	00	00
2	60	03	30	60	06	20	60	06	30
3	120	07	00	120	13	00	120	13	00
4									
1				0	00	00	0	00	00
2				45	05	20	45	05	30
3				90	10	00	90	10	00
4				135	15	20	135	15	30
5									
1				0	00	00	0	00	00
2				36	04	20	36	04	30
3				72	08	00	72	08	00
4				108	12	20	108	12	30
5				144	16	00	144	16	00
6									
1							0	00	00
2							30	03	30
3							60	07	00
4							90	10	30
5							120	14	00
6							150	17	30
7									
1							0	00	00
2							25	02	30
3							51	05	30
4							76	08	00
5							102	10	30
6							128	14	30
7							153	17	00
8									
1							0°	00'	00"
2							22	02	30
3							45	05	00
4							67	07	30
5							90	10	00
6							112	12	30
7							135	15	00
8							157	17	30

The Kern DKM-3 theodolite is an example of an instrument with a micrometer drum range of 5'. The Wild T-2 and the Kern DKM-2 theodolites are examples of instruments with a micrometer drum range of 10'.

* For Wild T-3 theodolites, with a 2' micrometer graduated to 0."2, the micrometer readings shown in the table as units would be in seconds.

** Repeating theodolite with a 10' circle.

*** Transit with a 20' circle.

RECORDING VERTICAL OBSERVATIONS

Recording vertical observations will be the same for all orders of accuracy. Vertical observations will be recorded in *DA Form 4446, Level, Transit, and General Survey Book*; authorized single sheet recording forms; or appropriate media when operating AISI. In all cases, complete documentation will be performed in the field. In addition to the recording requirements stated on page 6-1, the following information will be recorded:

- 1 The HI above the station will be measured and recorded to the nearest 0.01 meter.
- 2 The target observed will be sketched in the bottom of the Object Observed column, and the point of the target observed will be indicated.
- 3 The height of target observed (HT) above the station being observed will be measured and recorded to the nearest 0.01 meter.
- 4 If the observer and recorder show a target to adjoining stations, the target shown will be sketched at the bottom of the Remarks column. All possible points that may be observed on the target will be measured and recorded to the nearest 0.01 meter as heights above the mark at the station. If the observer and recorder change the target shown, they will remeasure all possible points, and record the new heights above station and the time of day when they changed the target.
- 5 If the target shown is not plumbed over the station, whether on line or eccentric, the recording requirements on page 6-1 will be strictly complied with.

During vertical observations, the time of the first observation of the first position and the time of the last observation of the last position will be recorded. The times will be recorded to the nearest whole minute.

The recording formats for the more commonly used instruments are shown at Figures 6-3 and 6-4 (pages 6-4 and 6-5). The T-2 theodolite and similar 1-second instruments observe zenith distances (Figure 6-3). The T-3 theodolite observes half-angles (Figure 6-4). The reverse (position) observation is subtracted from the direct (position). The difference is a vertical angle, with the algebraic sign indicating whether the vertical angle is elevated or depressed.

ABSTRACTING VERTICAL OBSERVATIONS

Vertical observations will be abstracted on *DA Form 1943, Abstract of Zenith Distances* (Figure 6-10), at the station site by the observing party.

Targets or signals shown to other stations will be sketched and dimensioned at the bottom of the form.

If a target or signal is changed during the day, the time of change and the new dimensions will also be entered.

Vertical observations recorded as vertical angles will be converted to zenith distances prior to abstracting. The zenith distances will be abstracted, including the times of the observations. The abstracted zenith distances will be meaned. The mean zenith distances will be reduced to corrected zenith distances, by applying the **reduction to line-joining stations**. The formula is –

$$\text{Reduction (in seconds)} = \frac{-(t - o) \sin mn \text{ Zenith Distance}}{T \sin 1''}$$

Where:

t = height of telescope above the station (HI)

o = height of object (point) observed above station

T = slope distance between stations (in kilometers)

This computation will also be applied to the vertical observations performed at the station at the other end of the line observed (reciprocal observations). The length of the line (T) will be multiplied by 0.46. Sum the two corrected zenith distances and subtract 180 degrees. Compare the product (T x 0.46) to the difference (corrZD1 + corrZD2 - 180 deg) (express as minutes of arc). If the two values differ by more than one minute of arc, perform a second set of reciprocal zenith distance observations. Differences exceeding one minute of arc are normally due to errors in observations, or unusual refractions in the atmosphere (poor observing conditions).

RECORDING HORIZONTALLY TAPED DISTANCES

Horizontally taped distances will be recorded in *DA Form 4196, Horizontal Distance Book*, or authorized single sheet recording form (Figure 6-11, page 6-18). The recorder will compute the horizontal distance in the recording book or form.

RECORDING ELECTRONICALLY MEASURED DISTANCES

Distances measured by EDM will be recorded on authorized single sheet recording forms (Figure 6-12, page 6-19). If the AISI is used, the appropriate recording media is authorized.

RECORDING DIFFERENTIAL LEVELING

Recording differential leveling is the same for all orders of accuracy. Differential leveling is recorded in *DA Form 4446* or authorized single-sheet recording forms (Figure 6-13, page 6-20). In addition to the

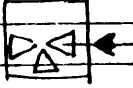
PROJECT			ABSTRACT OF ZENITH DISTANCES			
LOCATION			INSTR. (TYPE) (NO.)		STATION	
ORGANIZATION			OBSERVER		HEIGHT OF STAND	
DATE	TIME	OBJECT OBSERVED	OBJECT ABOVE STATION = 0 (Meters)	TELESCOPE ABOVE STATION = 1 (Meters)	DIFF OF HEIGHTS 1 - 0 (Meters)	REDUCED TO LINE JOINING STATIONS
1989						
2 Apr	1425	BROUIL	1.54	1.60 + 0.04		90° 04' 47.5"
	1430	(USACE) 1956				48.5"
		OBS CENTER OF TARGET				Ma 90° 04' 45.6"
sample						
DATE	LIGHT SHOWN TO STATION	HEIGHT OF LIGHT* ABOVE STATION (Meters)	DATE	LIGHT SHOWN TO STATION	HEIGHT OF LIGHT* ABOVE STATION (Meters)	
2 Apr 89		1.60 m at CENTER				
*Height of Light (or object above station) should also be entered on Abstract of Zenith Distances of station to which light was shown.						
COMPUTED BY	DATE	CHECKED BY	DATE			
SPC J. Jones	2 Apr 89	SGT W. Smith	2 Apr 89			
DA FORM 1943						
U.S. GPO: 1988-491-803/50457						
For use of this form, see TM 5-237; the proponent agency is TRADOC.						

Figure 6-10. Abstracting zenith distances

CHIEF TAPEMAN SP5 ORTON
DATE 14 JUNE 19 65
TAPE NOS. LUFWIN # 5216
LUFWIN # 3114
WEATHER CLOUD CLEAR, COOL

[illegible]

DA FORM 4196
1 JAN 74
(Blue)

Figure 6-11. Recording horizontal, taped distances

Field Sheet, Infrared							
For use of this form, see FM 5-232; the proponent agency is TRADOC.							
PROJECT <u>WEST RANGE ARTY 3.79</u>							
ORGANIZATION <u>99th ENGR CO.</u>				DATE <u>16 MAR 89</u>		APPROX DISTANCE <u>1500 m</u>	
ZERO CORRECTION * <u>-0.004</u>		CALIBRATION DATE <u>7 MAR 89</u>		OBSERVER <u>SPC WILSON</u>		RECORDER <u>PFC WHITE</u>	
INSTRUMENT STATION <u>ELKHORN (99th ENGR) 89</u>		H.I. <u>1.54M</u>		ELEVATION		ELEVATION INSTRUMENT	
REFLECTOR STATION <u>BULLRUSH (99th ENGR) 89</u>		H.I. <u>1.60M</u>		ELEVATION		ELEVATION REFLECTOR	
				ECCENTRICITY * TOWARD AWAY <u>0.000M</u>		INST NO <u>1268</u>	
				ECCENTRICITY * TOWARD AWAY <u>0.000M</u>		PRISM NO <u>R-1268</u>	
METEOROLOGICAL READINGS				ZD INSTRUMENT TO REFLECTOR			
	TIME	PRESSURE (Hg)	TEMP. (DRY)	DISTANCE (meters)			
		<u>mm</u>	<u>°C</u>	1	<u>1527</u>	<u>308</u>	
INSTRUMENT	<u>0819</u>	<u>762</u>	<u>76</u>	2	<u>1527</u>	<u>306</u>	
REFLECTOR	<u>0817</u>	<u>761</u>		3	<u>1527</u>	<u>311</u>	
	SUM	<u>1523</u>	<u>31</u>	4	<u>1527</u>	<u>306</u>	
	MEAN	<u>762</u>	<u>16</u>	5	<u>1527</u>	<u>306</u>	
CORRECTION FACTOR (PPM)		<u>+5</u>			<u>1527</u>	<u>307</u>	
PRODUCT = UD × PPM RC = PRODUCT × 10 ⁻⁶ T = UD ± Z ± RC H' = (T) ² - (d) ² H' = SIN ZD × T H _{FT} = H' × 3.280840				6	<u>1527</u>	<u>304</u>	
				7	<u>1527</u>	<u>310</u>	
				8	<u>1527</u>	<u>310</u>	
				9	<u>1527</u>	<u>310</u>	
				10	<u>1527</u>	<u>307</u>	
	SUM				<u>15273</u>	<u>075</u>	
UD	<u>1527.308</u>	MEAN UNCORRECTED SLOPE DISTANCE (UD)			<u>157.7</u>	<u>308</u>	
PPM	<u>+5</u>	ZERO CORRECTION ^o (Z)			<u>0</u>	<u>004</u>	
PRODUCT	<u>7636.540</u>	REFRACTIVE INDEX CORRECTION (RC)			<u>0</u>	<u>008</u>	
RC	<u>+0.008</u>	CORRECTED SLOPE DISTANCE (T)			<u>1527</u>	<u>312</u>	
DIFF. OF ELEV. (d)		UNCORRECTED HORIZON. DISTANCE (H')					
^o Obtained from Instrument Calibration. * Toward Eccentricity must be ADDED. Away Eccentricity must be SUBTRACTED.				ECCENTRIC CORRECTION * (EC)			
				HORIZON DISTANCE (H _M) / (H _{FT})			
REMARKS							
COMPUTED BY		DATE		CHECKED BY		PAGE OF	

Figure 6-12. Recording procedures for electronically measured distance (infrared)

[illegible]

Figure 6-13. Recording procedures for three-wire leveling

requirements on page 6-1, the names of the rodmen (and umbrellaman, when applicable) will be recorded.

Determining and recording mean centerwire reading to four decimal places –

Ž If the top interval is LARGER than the bottom, ADD the correction to the recorded centerwire reading to obtain the mean centerwire value to four decimal places.

Ž If the top interval is SMALLER than the bottom, SUBTRACT the correction from the recorded centerwire reading to obtain the mean centerwire value to four decimal places.

Maximum permissible
interval imbalance = 3 (third-order)

Difference in Intervals	Centerwire Correction
0.000	0.0000
0.001	0.0003
0.002	0.0007
0.003	0.0010

Maximum permissible
interval imbalance = 2 (second-order)

Difference in Intervals	Centerwire Correction
0.000	0.0000
0.001	0.0005
0.002	0.0010

DETERMINATION OF C FACTOR

Each day, just before differential leveling begins or immediately following any instance when the instrument is subjected to unusual shock, the error of the level (C factor) must be determined. The determination of C may be performed as a part of a leveling line or separately. In all cases, the C factor determination recordings must be separate from other recordings and comply with all requirements for note keeping.

It is desirable to determine the C factor under the same conditions that the leveling will be performed, including length of sight, slope of ground, and elevation of the line of sight above the ground.

If C is determined during the first setup of the leveling, perform the following sequence of events:

1. After the regular foresight observations are recorded for the level line, record the foresight readings on the C factor note sheet.
2. Call up the rear rodman to approximately 10 meters behind the level.
3. Observe and record the rear rod readings on the C factor note sheet,
4. Move the level to approximately 10 meters behind the front rod.

5. Read and record the front rod on the C factor note sheet.

6. Read and record the rear rod on the C factor note sheet.

Ensure that the circular bubble is carefully centered and that the observed ends of the bubble in the tubular level vial are in coincidence (when applicable) prior to reading the three wires.

The C factor is determined using the formula:

$$C = \frac{\begin{array}{c} \text{(sum of near rod} \\ \text{mean readings)} \end{array} - \begin{array}{c} \text{(sum of corrected far} \\ \text{rod mean readings)} \end{array}}{\begin{array}{c} \text{(sum of far} \\ \text{rod intervals)} \end{array} - \begin{array}{c} \text{(sum of near} \\ \text{rod intervals)} \end{array}}$$

The total correction for curvature and refraction (Table 6-2) must be determined for each far rod reading, using the distance from the instrument to the far rod as the argument. Distances equal the product of the sum-of-the intervals (for a single set of three-wire readings) times the stadia interval factor (SIF). The two corrections for curvature and refraction are algebraically added to the sum of the mean wire readings for the distant rod. The maximum permissible C factor varies with the SIF. Instruments with an SIF of 1:100 may not have a C factor of greater than ± 0.004 . Instruments with a SIF of 1:200 may not have a C factor of greater than ± 0.007 . Instruments with a SIF of 1:333 may not have a C factor of greater than ± 0.010 . If the C factor is determined to be greater than what is permitted for the instrument's SIF, the instrument must be adjusted and the C factor redetermined before performing differential leveling operations. The notes for the C factor determination become a part of the administrative notes for the leveling operation (Figure 6-14, page 6-23).

CENTERWIRE ADJUSTMENT

If the C factor exceeds the limits (as established by the SIF), a correction to the centerwire must be made.

The correction to the centerwire is determined by multiplying the total rod interval of the last foresight (distant rod) by the computed C factor. Compute the correction to three places to the right of the decimal point and include the algebraic sign of the C factor.

The correction to the centerwire is algebraically added to the last foresight mean wire reading. The result will be the corrected centerwire reading. Compute the corrected centerwire reading to three places to the right of the decimal point (Figure 6-14).

Following the manufacturer's manual, adjust the level until the corrected centerwire reading is observed on the distant rod. Perform the C factor

determination again to ensure that the new C factor is within the acceptable limits.

DETERMINATION OF STADIA INTERVAL FACTOR

The SIF is required to compute the length (horizontal distance) from the stadia intervals and to determine the maximum allowable error for a level line. The SIF must be determined if the reticle (which contains the etched stadia wires) is replaced or changed in the level. The notes from the SIF determination become a permanent part of the records kept with the level, as well as being kept with the project files (Figure 6-15, page 6-24).

The SIF determination is made by comparing the stadia intervals observed over a course of known distances. Lay out the course on a reasonably level track, roadway, or sidewalk. Place nails or other marks in a straight line of measured distances of 0, 25, 35, 45, 55,

65, and 75 meters. Plumb the optical zero point of the level over the zero marker on the ground and level the instrument. The optical zero point of the level will be found in the manufacturer's manual. Read the rod at each of the six points and record the intervals. Compute the half-wire intervals as a check against erroneous readings. Compute the sum of the total intervals for the six readings. The SIF will be the sum of the measured distances (300 meters) divided by the sum of the six total intervals.

To check for errors, compute the SIF for each of the six readings and divide the measured distance by the total interval observed for that distance. The average of the six computations will serve as a numerical check. A tendency for the six computed values to creep in one direction indicates an error in plumbing the optical zero point of the level over the zero point on the ground.

Table 6-2. Correction for curvature and refraction (leveling)

This table of total correction for curvature and refraction is for use in computing "C" and in general wherever the total correction is required. In computing this table, the refraction was assumed to equal one-eighth the curvature.

Distance (meters)	Correction to rod (mm)	Distance (meters)	Correction to rod (mm)	Distance (meters)	Correction to rod (mm)
0 to 27	0.0	125 to 130	-1.1	210	-3.0
28 to 47	-0.1	131 to 136	-1.2	220	-3.3
48 to 60	-0.2	137 to 141	-1.3	230	-3.7
61 to 72	-0.3	142 to 146	-1.4	240	-4.0
73 to 81	-0.4	147 to 150	-1.5	250	-4.3
82 to 90	-0.5	160	-1.8	260	-4.7
91 to 98	-0.6	170	-2.1	270	-5.0
99 to 105	-0.7	180	-2.3	280	-5.4
106 to 112	-0.8	190	-2.6	290	-5.8
113 to 118	-0.9	200	-2.8	300	-6.2
119 to 124	-1.0				

[illegible]

Figure 6-14. Determination of C factor and centerwire adjustment

Three-Wire Leveling

For use of this form, use FM 5-232; the proponent agency is TRADOC.

STATION	ROD READING	INTERVAL	SUM OF INTERVALS	CHECK	REMARK
25	1355	125	250	25 / 250 = 0.100	
35	1425	175	350	35 / 350 = 0.100	
45	1486	226	452	45 / 452 = 0.100	
55	1505	275	550	55 / 550 = 0.100	
65	1545	325	650	65 / 650 = 0.100	
75	1675	375	749	75 / 749 = 0.100	
TOTAL			3001	300 / 3001 = 0.100	CHECK

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Figure 6-15. Determination of stadia interval factor