



Input Formats and Specifications of the National Geodetic Survey Data Base

Volume II. Vertical Control Data

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(See Volume I for Annex A through Annex N)

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PREFACE

"Input Formats and Specifications of the National Geodetic Survey (NGS) Data Base," commonly called the "Blue Book," is a user's guide for preparing and submitting geodetic data for incorporation into NGS' data base. Survey data that are entered into NGS' data base become part of the National Spatial Reference System (NSRS), formerly the National Geodetic Reference System. The guide comprises three volumes. Volume I covers classical horizontal geodetic and Global Positioning System (GPS) data, volume II covers vertical geodetic data, and volume III covers gravity data. Beginning with this edition, the three formerly separate volumes are distributed as a set, since a great deal of information is common to each volume. Because some of the chapters and annexes are identical in all three volumes, the original numbering design has been retained.

The formats and specifications are consistent with the aims of the Executive Office of the President, Office of Management and Budget's (OMB) Circular A-16, as revised in 1990. A major goal of the circular, which is titled "Coordination of Surveying, Mapping, and Related Spatial Data Activities," is to develop a national spatial data infrastructure with the involvement of Federal, state, and local governments, and the private sector. This multilevel national information resource, united by standards and criteria established by the Federal Geodetic Control Subcommittee (FGCS) of the Federal Geographic Data Committee (FGDC), will enable the sharing and efficient transfer of geospatial data between producers and users.

Survey data that are submitted to NGS for incorporation into NSRS should be properly formatted and supply minimum accuracies of:

First-order horizontal accuracy standards for GPS and conventional horizontal surveys;

Second-order, class II vertical accuracy standards for conventional leveling;

Third-order gravity standards for gravity surveys.

Effective July 1, 1995, survey project data must meet the above minimum accuracy standards to be accepted for inclusion into the NGS data base. Surveys that are of lower order than given above will be accepted only in exceptional cases approved by the Chief, NGS.

In addition, these data standards and accuracies should be verified and the survey data contributed for inclusion into the NGS data base should be processed and adjusted by the provider, using currently available NGS software, before submitting the survey project to NGS.

At this time, NGS provides review, archiving, and distribution functions free of charge for survey data submitted in the proper format. These surveys must contain connections to NSRS in accordance with FGCS Standards and Specifications and they must contribute to the public good.

The production of the Blue Book entailed significant contributions from a number of NGS employees. Notable among these are D. Sherrill Snellgrove for his revision of Volume I, originally prepared by then-Commander Ludvik Pfeifer, NOAA (Ret.); Nancy L. Morrison and Commander Pfeifer, for their contributions to preparing Volume II; and then-Lieutenant Warren T. Dewhurst, NOAA, for his preparation of Volume III.

This publication and most of the documents referenced herein may be obtained from:

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NOTE: Volume I (Chapters 1-3, Annexes A-I,K,L,N) contains input formats and specifications for horizontal control data, and Volume III (Chapters 9-11, Annex O) contains input formats and specifications for gravity control data.

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Chapter 5

VERTICAL CONTROL (VERT) DATA

INTRODUCTION

For coding and processing purposes, the data associated with geodetic vertical control (VERT data) have been divided into three groups. The three vertical control data groups are (1) the field observations of elevation differences between survey points (OBS data), (2) descriptive data including original descriptions and recovery descriptions (DESC data), and (3) adjusted elevations (ELEV data). Detailed instructions and formats for the coding and keying of the OBS, DESC, and ELEV vertical control data sets are contained in Chapters 6, 7, and 8, respectively.

Although data of all three types are normally generated in connection with a vertical control survey project, OBS, DESC, and ELEV data must be submitted to NGS as separate data sets. There are two modes in which vertical control data may be submitted to NGS for insertion in the National Geodetic Survey Data Base. In order of preference, they are:

MODE 1 - Field Observations and Descriptive Data (VERT OBS and VERT DESC data)

MODE 2 - Adjusted Elevations and Descriptive Data (VERT ELEV and VERT DESC data).

The foregoing implies that every vertical control survey project (or several projects submitted as one "job" - see below) will be received at NGS as two distinct data sets: either OBS and DESC data sets under MODE 1, or ELEV and DESC data sets under MODE 2. The two data sets of each vertical control job must be submitted at the same time.

There are distinct benefits to be realized when vertical control data intended for insertion in the National Geodetic Survey Data Base are submitted in the MODE 1 configuration. Because the field observations which connect the survey points are given, MODE 1 data can be rigorously combined with data held by NGS and incorporated (adjusted) into the national vertical control network. This process insures that the elevations of the new survey points will be consistent with the existing vertical control in that area. By contrast, MODE 2 data consist of isolated points whose elevations are accepted as determined by the submitting agency. Because the connecting observations are not available, these elevations cannot be verified, and they cannot be rigorously updated when the vertical control network in their vicinity is readjusted.

For reasons cited in the preceding paragraph, vertical control data intended for insertion in the National Geodetic Survey Data Base should be submitted as MODE 1 data. MODE 2 data will be accepted only on an exception basis after consultation between NGS and the submitting agency.

JOB CODE AND SURVEY POINT NUMBERING

The basic unit or grouping of data to be submitted is given the name "job". A vertical control job may consist of data for a maximum 9999 survey points - see definition of "survey point" below. A job may consist of a single project (i.e., one unit of field work), or a number of projects may be included in one job. It is suggested that geographic proximity be the determining factor in selecting vertical control projects for inclusion in any one job. This approach eliminates duplicate keying of DESC data for vertical control survey projects which have points in common (e.g., a releveling over a previously established line, when both projects are to be submitted for insertion in the National Geodetic Survey Data Base).

A two-character alphanumeric code must be assigned to each vertical control job submitted by an agency in accordance with this publication. This job code, the data set type, the name of the submitting agency, and the data set creation date will serve to uniquely identify every data set received by NGS. The first character of the two-character job code must always be a letter; the second character may be either a letter or a number (1 through 9). Begin the assigning of job codes with A1 and end with ZZ, i.e., A1, A2, ..., B1, ..., Z1, ..., Z9, AA, AB, ..., ZZ. This allows for a total of 910 uniquely identified vertical control jobs to be submitted by any one agency. Should this sequence be exhausted, start assigning job codes again from the beginning: A1, A2, etc.

A vertical control point is defined as a survey point which is monumented (or otherwise permanently marked) and/or described and whose (adjusted) elevation is given (ELEV data), whose elevation is to be determined in an adjustment (OBS data), or whose elevation is available from other sources. A vertical control point is commonly known as a "bench mark" (BM). A survey point, in turn, is defined as any point which has one or more elevation differences measured to it or from it. A survey point may be a temporary bench mark (TBM, neither permanently marked nor described and therefore nonrecoverable), a described TBM, or a permanent bench mark (monumented and described). Henceforth, the term "bench mark" will be understood to also include the special class of described temporary bench marks (TBMs).

Each survey point that is leveled to in a vertical control job must be assigned a unique four-digit serial number (not necessarily consecutive)

LEGEND

- Bench Mark
- Temporary Bench Mark
- ⊗ Junction TBM

- Epoch 1 Project
- - - - Epoch 2 Project
- Epoch 3 Project

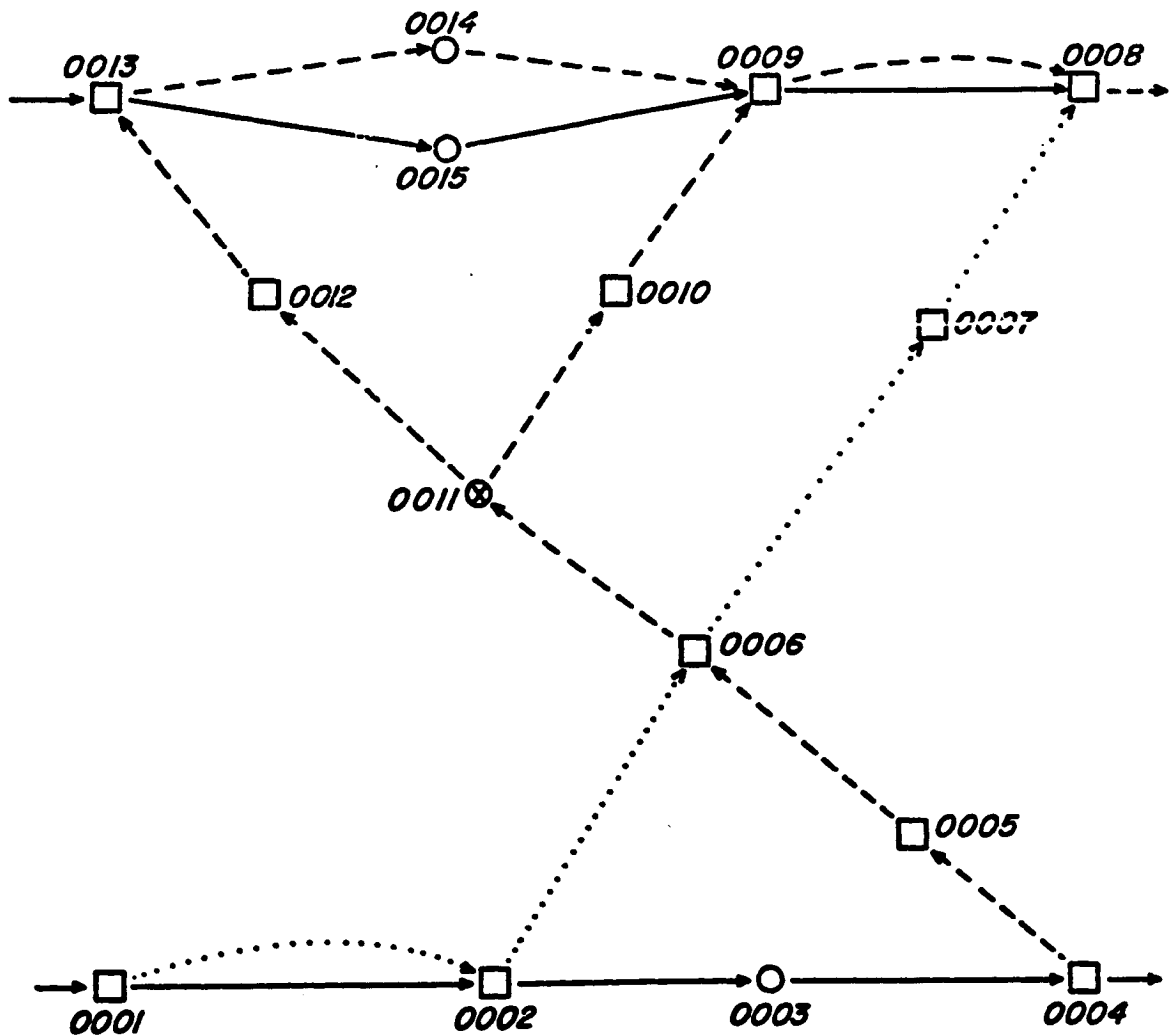


FIGURE 5-1 - Example of vertical survey point numbering.

in the range 0001 through 9999. If the number of survey points exceeds 9999, the vertical control data in question must be divided and submitted as two or more jobs. In general, level lines should not be subdivided. Figure 5-1 illustrates the assignment of survey point serial numbers (SPSNs). This numbering system provides a unique identifier for every survey point which is leveled in a vertical control job. The same survey point serial number (SPSN) must be consistently used whenever reference is made to the same point in either the OBS, DESC, or ELEV data sets of a vertical control job. All survey points for which recovery descriptions are written in this current project, but which are not leveled in this current project, will be assigned the SPSN code 0000.

As pointed out in the INTRODUCTION, a vertical control job consists of two separate data sets - either the VERT OBS and VERT DESC data sets under MODE 1, or the VERT ELEV and VERT DESC data sets under MODE 2. When MODE 2 data are submitted, there will be one-to-one correspondence between points in the respective ELEV and DESC data sets, because every control point in the ELEV data set must also have an original description and/or recovery description(s) in the corresponding DESC data set. When MODE 1 data are submitted, however, there will normally be a greater number of points in the OBS data set than in the corresponding DESC data set. This condition is brought about by the fact that there are, in general, temporary bench marks (TBMs) in the OBS data set for which no descriptive data have been prepared. It must be emphasized, however, that descriptive data should exist for all recoverable vertical control points.

When the data-recording medium is magnetic tape (see below), the two data sets of a vertical control job must be submitted as two separate files. These files may be on the same reel of tape or on different reels if the data are organized so that a tape contains data sets of only one type (e.g., VERT OBS data sets) when many jobs are being submitted. When the data-recording medium is punched cards, the two data sets must be submitted as two separate decks. In any case, the first record of every data set (see Chapters 6, 7, and 8) must contain the information by means of which the respective data sets are positively identified and correlated - the job code, the data set type, the name of the submitting agency, and the data set creation date.

MEDIA FOR SUBMITTING DATA

Although in principle any computer-readable, general-purpose data-recording medium can be handled, the two media acceptable to NGS on a routine basis at the present time are punched cards (80 columns) and standard 1/2-inch magnetic tape. Magnetic tape is the preferred medium for both small and large volumes of data; agencies submitting

large volumes of data should use this medium exclusively. Punched cards should be used only for small, isolated jobs.

When the data are submitted as decks of punched cards, care must be taken to package each deck separately in order to minimize the likelihood of cards from different decks becoming intermingled. Provision is made for a sequence number to appear on every card of a deck; however, only the first card of each deck contains the deck identification data. The following information must be given for each data set submitted as a deck of cards:

1. Name and address of the submitting agency.
2. Contents of the deck by job code and data type (e.g., A1 VERT OBS, XX VERT DESC, etc.).
3. Character representation code (BCD, EBCDIC, etc.) and/or keypunch equipment used (e.g., IBM 026, IBM 029, etc.).
4. Name and telephone number of person to be contacted in case of difficulty with the data.

This information should be given in a letter of transmittal, a copy of which should be packed with the data set in question.

When the data are submitted as files of formatted records on magnetic tape, the following information is expected to be given for each reel of tape:

1. Name and address of the submitting agency.
2. Reel number or identification symbol assigned by the submitting agency.
3. Number of files and contents of each file by job code and data type (e.g., A1 VERT OBS, XX VERT DESC, etc.).
4. Computer system on which the tape was created (e.g., IBM 360/XXX, CDC 6600, etc.).
5. Internal label information (e.g., non-labeled, standard IBM label, etc.).
6. Number of tracks (7 or 9) and parity (even or odd).
7. Recording density (556, 800, or 1600 BPI).
8. Record length (LRECL) and block size (BLKSIZE).

9. Character representation code (BCD, EBCDIC, etc.) and keytape equipment designation, if applicable.
10. Name and telephone number of person to be contacted in case of difficulty with the data.

In addition to being given in the respective letter of transmittal, this information should be entered on one or more "stick-on" labels affixed to the magnetic tape reel.

A letter of transmittal in which the data are described and itemized should always be prepared for each data shipment. One copy should be enclosed with the data shipment, one sent by separate mail to NGS, and another copy should be retained by the sender. See ANNEX K for the current mailing instructions. In every case, the submitting agency should retain a backup copy of all data included in a shipment until the receipt of that specific data is acknowledged by NGS.

CODING, KEYING, AND DATA VERIFICATION

All data submitted to NGS for insertion in the National Geodetic Survey Data Base must be coded and keyed in strict conformity with the formats and specifications contained in this publication. In addition, the keying of all data must be verified. Detailed formats and specifications for the coding and keying of vertical control jobs are contained in Chapter 6 (VERT OBS data), Chapter 7 (VERT DESC data), and Chapter 8 (VERT ELEV data). The formats were designed to allow the keying and verification of the data to be accomplished on standard keypunch or keytape equipment. The 80-character record (one punched card image) has been adopted for all applications.

In keying the data entries, care must be taken to insure that alphabetic characters (letters) are always keyed using the alphabetic keys on the keying device, and that numeric characters (numbers) are always keyed using numeric keys. In particular, the miskeying of the following characters must be avoided:

0 - number "zero"	1 - number "one"	2 - number "two"
0 - letter "O"	L - letter "L"	Z - letter "Z"

SPECIAL CHARACTERS

In addition to alphabetic characters (letters A through Z) and numeric characters (numbers 0 through 9), the following special characters are allowed:

(*) asterisk	(+) plus sign
() blank or space	(-) minus sign or hyphen
(,) comma	(=) equal sign
(.) period or decimal point	(/) slash or solidus
(\$) dollar sign	(() left parenthesis
	()) right parenthesis

NOTE: A further restriction on characters is imposed for Bench Mark designations (see Annex D).

SEQUENTIAL RECORD NUMBERING

The first six characters of every record are reserved for a record sequence number. The purpose of the sequential numbering of records is to insure that the proper sequence of individual records in a data set can be verified and, if necessary, restored. The record sequence numbers must form one continuing sequence throughout each data set, starting with the first record (the Data Set Identification Record) and ending with the last record (the Data Set Termination Record).

Start with assigning sequence number 000010 to the first record in the data set (the Data Set Identification Record) and increment by 10 on each successive record. This numbering system allows up to nine records to be inserted between any two originally numbered records without the necessity of renumbering any records in the data set. Even when a large block of omitted records must be inserted, only a few of the existing records will have to be renumbered. However, to allow for the detection of missing records, all insertions and/or deletions which cause deviation from the basic 000010, 000020, 000030, etc. "increment-by-ten" record sequence must be accounted for in the respective letter of transmittal.

Discounting any after-the-fact insertions, the above-described sequential numbering system will permit a maximum of 99,999 uniquely numbered records in any one data set. Should there ever be a need for a greater number of records in a data set, retain only the last six digits of the higher sequence numbers, i.e., ... 999980, 999990, 000010, etc.

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Chapter 6

VERTICAL OBSERVATION (VERT OBS) DATA

INTRODUCTION

The purpose of this chapter is to provide detailed specifications and instructions for the coding and keying of the observation data set of a vertical control job. As was explained in Chapter 5, a vertical control job consists of two distinct data sets which must be submitted together. The companion data set to the vertical observation (VERT OBS) data set treated in this chapter is the data set containing original descriptions and/or recovery descriptions for the control points which occur in the vertical control job. This descriptive (VERT DESC) data set is treated in Chapter 7.

VERT OBS DATA SET RECORDS

The data which constitute a VERT OBS data set are organized into four categories:

1. Line Identification Data
2. Survey Equipment Data
3. Field Abstract Data
4. Observation Data

Within these categories, the respective data have been grouped into one or more logical units called "records." A record is a string of characters containing data coded according to a specific format. Every record in a VERT OBS data set consists of 80 characters or "columns" (standard punched card image). Within each record, the 80 columns are divided into fixed-length "character fields," each field being the space reserved for a specific data item. Accordingly, for every desired data item, there exists a field of appropriate length into which the data item in question is to be entered after it is converted into a string of alphanumeric characters. The set of rules according to which specific data items are converted into strings of alphanumeric characters to be entered in the fields of a record is known as the "format" of that record.

The types of records which may appear in a VERT OBS data set are listed in Table 6-1. Each type of record has been given a name, and a block diagram illustrating the respective format has been prepared to serve as a model for that record - see FORMAT DIAGRAMS.

Except for the first and last records of the data set, the second character field of each record (columns 7-10) contains a two-digit numerical data code, preceded and followed by an asterisk, which specifies the type of that record (*10*, *11*, ..., *43* - see Table 6-1). The first and last records of the data set (the Data Set Identification Record and the Data Set Termination Record) display the two-character alphanumeric job code assigned by the submitting agency in this field (*A1*, *A2*, ..., *ZZ* - see Chapter 5). The first character field of every record (columns 1-6) is reserved for the respective record sequence number - see Chapter 5. The remaining portion of each record (columns 11-80) contains character fields which are peculiar to each individual record type.

TABLE 6-1
VERTICAL OBSERVATION DATA SET RECORDS

FIRST RECORD

AA - Data Set Identification Record

LINE IDENTIFICATION DATA

- *10* - Line Information Record
- *11* - Line Title Record (Optional)
- *12* - Line Title Continuation Record (Optional)
- *13* - Line Title Continuation Record (Optional)
- *14* - Line Title Continuation Record (Optional)
- *15* - Comment Record (Optional)

SURVEY EQUIPMENT DATA

- *20* - Instrument Information Record
- *21* - Rod Information Record
- *22* - Rod Standardization Record
- *23* - Rod Calibration Record

FIELD ABSTRACT DATA

- *30* - Field Abstract Record

OBSERVATION DATA

- *40* - Survey Equipment Record
- *41* - Running Record
- *42* - River/Valley Crossing Record
- *43* - Correction/Rejection Record

LAST RECORD

- *AA* - Data Set Termination Record

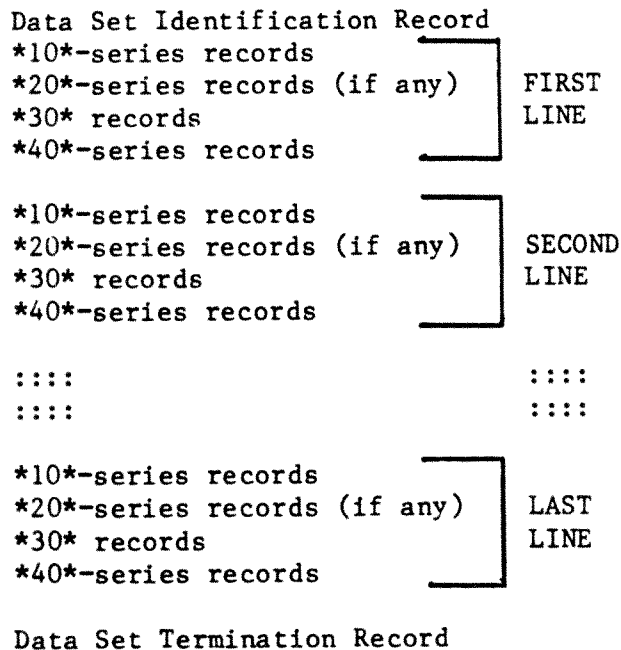
Note: The symbol *AA* denotes the two-character job code assigned by the submitting agency - see Chapter 5.

STRUCTURE OF THE VERT OBS DATA SET

The first record of a VERT OBS data set must be the Data Set Identification Record which contains the required information to identify the data set and to correlate it with its companion VERT DESC data set - job code, data type (VERT OBS), name of submitting agency, and date the data set was created. The last record of the data set must be the Data Set Termination Record. It is the only other record in the data set on which the respective job code appears in the same field (columns 7-10) as on the Data Set Identification Record.

The VERT OBS data set records which are bracketed by these two delimiting records may pertain to one or more units of field work; i.e., field observation data for several leveling lines may be submitted in one VERT OBS data set under the same job code, provided that the total number of survey points (bench marks and temporary bench marks) in the job does not exceed 9,999 (see Chapter 5). When two or more leveling lines are included in a vertical control job, each line must appear as a complete unit in the respective VERT OBS data set, i.e., as a block of records which contains all information pertinent to that line (see table 6-2). Each line must begin with a *10* record, contain any appropriate number of the other types of records in proper sequence, followed by one or more *40 - series records.

TABLE 6-2
STRUCTURE OF THE VERT OBS DATA SET



A leveling line is a unit of field work consisting of a number of survey points (bench marks and temporary bench marks - see Chapter 5) which are connected by chains of differential leveling observations called "runnings." When coded as part of a VERT OBS data set, a leveling line is a block of records comprising record groups arranged in the following order:

1. Line Identification Data (*10*-Series) Records:

- *10* record
- *11* record (optional; possibly *12*, *13*, and *14* records as well)
- *15* records (optional, any number allowed)

2. Survey Equipment Data (*20*-Series) Records:

- *20* records (at least one if instrument not previously reported; in general, one for each previously unreported stadia factor determination) for the first instrument used
- *20* records (at least one if instrument not previously reported; in general, one for each previously unreported stadia factor determination) for the second instrument used
- ::::
- *20* records (at least one if instrument not previously reported; in general, one for each previously unreported stadia factor determination) for the last instrument used
- *21*, *22*, and/or *23* record(s) - *21* record alone if rod not previously reported and no standardization or calibration data are available; in general, one *21* record followed by one or more *22* records (one for each previously unreported rod standardization), one or more *22*, *23*,..., *23* record sets (one such set for each previously unreported single-temperature rod calibration), and/or one or more *23*, *23*,..., *23* record sets (one such set for each previously unreported multiple-temperature rod calibration with one or more *23* record(s) for each calibration temperature) - for the first rod used
- *21*, *22*, and/or *23* record(s) - *21* record alone if rod not previously reported and no standardization or calibration data are available; in general, one *21* record followed by one or more *22* records (one for each previously unreported rod standardization), one or more *22*, *23*,..., *23* record sets (one such set for each previously unreported single-temperature rod calibration), and/or one or more *23*, *23*,..., *23* record sets (one such set for each previously unreported multiple-temperature rod calibration with one or more *23* record(s) for each calibration temperature) - for the second rod used
- ::::
- *21*, *22*, and/or *23* record(s) - *21* record alone if rod not

previously reported and no standardization or calibration data are available; in general, one *21* record followed by one or more *22* records (one for each previously unreported rod standardization), one or more *22*, *23*, ..., *23* record sets (one such set for each previously reported single-temperature rod calibration), and/or one or more *23*, *23*, ..., *23* record sets (one such set for each previously unreported multiple-temperature rod calibration with one or more *23* record(s) for each calibration temperature) - for the last rod used

Note that for instruments and/or rods which are used in more than one leveling line submitted in the same or in different vertical control jobs, it is not necessary to repeat the same *20*-series records in each such line or each such VERT OBS data set. It is sufficient to submit the respective *20*-series records once as part of the first line submitted in which such instruments and/or rods appear, and thereafter only if the stadia factor is redetermined for an instrument and/or if a rod is restandardized or recalibrated - see SURVEY EQUIPMENT DATA RECORDS.

3. Field Abstract Data (*30*) Records:

30 records - one for the first (starting) survey point (bench mark or temporary bench mark) followed by one *30* record for each elevation carried forward to a survey point along the leveling line.

The order of the *30* records is important; normally they should follow in sequence as the respective survey points (bench marks and temporary bench marks) occur along the leveling line. However, one or more spurs may emanate from any given survey point - in which case, after the *30* record for such a "base" point, the *30* records for all survey points along the longest spur must follow first, then those along the next-longest spur, etc. Only when all spurs emanating from that base point have thus been exhausted, should the *30* record for the elevation carried forward to the next survey point along the main route be given - see example in Figure 6-1.

In the absence of any closed loops, there will be as many *30* records as there are survey points along the leveling line. However, if a loop is closed (as in the case of a spur loop or if the line itself forms a closed loop), an additional *30* record must appear in proper sequence (see above) for the endpoint of every such loop, reflecting the elevation carried forward to that bench mark or temporary bench mark via the loop.

4. Observation Data (*40*-Series) Records:

40 record giving the date, instrument/rod combination, and collimation error data for the first set of runnings
41 record for the first running in the first set
43 record (if needed) for the first running in the first set
41 record for the second running in the first set
43 record (if needed) for the second running in the first set
::::
41 record for the last running in the first set
43 record (if needed) for the last running in the first set
40 record giving the date, instrument/rod combination, and collimation error data for the second set of runnings
41 record for the first running in the second set
43 record (if needed) for the first running in the second set
41 record for the second running in the second set
43 record (if needed) for the second running in the second set
::::
41 record for the last running in the second set
43 record (if needed) for the last running in the second set
::::

40 record giving the data, instrument/rod combination, and collimation error data for the last set of runnings
41 record for the first running in the last set
43 record (if needed) for the first running in the last set
41 record for the second running in the last set
43 record (if needed) for the second running in the last set
::::
41 record for the last running in the last set
43 record (if needed) for the last running in the last set
42 record for the first river/valley crossing along the line
43 record (if needed) for the first river/valley crossing along line
42 record for the second river/valley crossing along the line
43 record (if needed) for the second river/valley crossing along line
::::
42 record for the last river/valley crossing along the line
43 record (if needed) for the last river/valley crossing along line

LINE IDENTIFICATION DATA RECORDS

10 Line Information Record
11 Line Title Record (Optional)
12 Line Title Continuation Record (Optional)
13 Line Title Continuation Record (Optional)
14 Line Title Continuation Record (Optional)
15 Comment Record (Optional)

The line identification data records, bearing the *10*-series data codes, are listed above; the block diagrams illustrating the respective formats will be found under FORMAT DIAGRAMS.

The *10* record contains essential line identification data and is always required. The *11* record is optional; however, it is highly desirable that a line title (reflecting the geographic location of the line - see below) be given. The line title should be concise so as to fit on the *11* record (up to 70 characters); however, one, two, or three continuation records (the *12*, *13*, and *14* records) may be appended if the title is lengthy or if a main title followed by subtitle(s) is called for. Following the *11* record (or else the last title continuation record), there may appear as many *15* records as appropriate to give comments pertinent to the leveling line (e.g., significant problems encountered, deviations from standard procedures, etc.), if any.

The entries on these records (see FORMAT DIAGRAMS) are for the most part self-explanatory; however, the following data items will be explained in greater detail:

Leveling Line: As was stated in the preceding section, a leveling line is a unit of field work consisting of a number of survey points (bench marks and temporary bench marks) which are connected by chains of differential leveling observations called "runnings." Each segment of a leveling line consisting of two neighboring survey points connected by a running is called a "section" of the leveling line.

The objective of differential leveling is the extension of vertical control by precise determination of differences of elevation between successive survey points along the leveling line. The end product is a string of permanently marked vertical control points or bench marks (BMs).

Tolerance Factor: To control the accumulation of error in the differential leveling process, each section of a leveling line is normally "double-run," i.e., observed twice by runnings in opposite directions, and the disagreement between the respective differences of elevation as determined by the two runnings must not exceed a tolerance limit computed as the product of the appropriate tolerance factor and the square root of the section length.

Aside from the units of measurement involved, the numerical value of the tolerance factor used for this purpose depends on the type and intended accuracy of the vertical control survey in question; it is one of the specification parameters which characterizes a given order and class of vertical control survey (see below).

Note that the tolerance factor is expressed in mixed units, i.e., in "Units of Elevation-Difference Disagreement Per Square-Root of Units of Section Length." For the purposes of this publication two such unit combinations are allowed (must be specified by the respective units code given as part of the tolerance factor data group on the *10* record):

1. Millimeters per square-root of kilometers (units code MM), and
2. Feet per square-root of statute miles (units code FT).

Order and Class of Survey: A two-digit code is provided on the *10* record to specify the order of accuracy of the survey. The first digit of this code reflects the order and the second digit the class of the survey in accordance with the "Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys," prepared by the Federal Geodetic Control Committee (FGCC), and published by the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, Rockville, MD (February 1974). In addition to the five vertical control survey categories defined in this publication, three other survey categories need to be considered - old vertical control surveys of first or second order for which no class is specified, and surveys of lower-than-third-order accuracy. The respective two-digit codes are as follows:

- 10 - First-Order (Class Unspecified)
- 11 - First-Order, Class I
- 12 - First-Order, Class II
- 20 - Second-Order (Class Unspecified)
- 21 - Second-Order, Class I
- 22 - Second-Order, Class II
- 30 - Third-Order
- 40 - Lower-Than-Third-Order

Remove this classification in next revision

not used

The order-and-class code assigned to a leveling line should reflect the procedures and specifications according to which that entire line has been observed. When well-defined segments of a leveling line fall into different order-and-class categories, the line must be divided accordingly and the respective parts submitted as separate lines.

State or Country Code: Provision is made on the *10* record to indicate the political unit(s) and/or geographic area(s) in which the leveling line is located using the two-letter state or country codes given in ANNEX A. Up to three such codes may be entered, in the order of progress along the line in question. In the United States or in Canada, enter the appropriate code for the respective state, commonwealth, province, or territory; elsewhere enter the appropriate code for the respective country, island group, or geographic area - see ANNEX A.

Line Title: The desired elements of information in the title of a leveling line are (1) the respective line number or other identification symbol, (2) the order of accuracy of the survey, (3) whether original leveling or releveling, and (4) the geographic locality (or localities) of the survey. Since the first three elements are explicitly coded on the *10* Line Information Record (see FORMAT DIAGRAMS), it would be superfluous to repeat them in the line title, and hence only the geographic location needs to be specified. The use of geographic location alone as the title of a leveling line has traditionally been the practice of the NGS and its predecessors.

In general, the title by which the leveling line is known to the submitting agency should be given, supplemented to reflect geographic location, as required. Omit punctuation marks (periods, commas, etc.) and parentheses whenever their omission can be tolerated, and use ANNEX A state and country codes whenever reference to a state or country is necessary. Furthermore, edit and/or abbreviate the line title in the interest of fitting the entire title on the *11* Line Title Record, if at all possible. However, up to three additional records (the *12*, *13*, and *14* Line Title Continuation Records) may follow the *11* Line Title Record if the title must be lengthy or when a main title followed by one or more subtitles is desired.

The geographic location of the leveling line should be descriptive of the route followed, i.e., the starting locality, any prominent "via" points, and the ending locality should be specified in the order of progress of the survey (Example: ALBANY GA VIA MORVEN TO CALLAHAN FL). If the leveling line is a member of a special project or of an area network to which a specific name or title has been assigned, such a name or title should be carried as a main title on the *11* record and the title of the line proper should follow as a subtitle on one or more of the continuation records. Example:

11 Record: TULARE-VASCO ARVIN-MARICOPA AREA CA
12 Record: 9.1 KM SE OF KETTLEMAN CITY TO PIXLEY .

DATE AND TIME

Date of the VERT OBS data set creation must appear on the Data Set Identification Record, and the dates on which survey operations commenced and terminated are to be entered on the *10* Line Information Record. In addition, character fields are reserved for the date and/or time on several other records of the VERT OBS data set. Throughout the VERT OBS data set, date and time are to be coded as follows:

Date: Full date is coded as an eight-digit integer number consisting of four two-digit groups denoting (from left to right) the last whole century, number of full years since the turn of century, month of the year, and day of the month (CCYYMMDD). For the 20th

century, the "century" columns may be omitted, and the date coded as a six-digit integer number denoting the year, month, and day (YYMMDD). If the day is not known (e.g., in connection with old data extracted from archives for which the date is not fully specified), leave the last two columns of the field blank; if the month is not known, leave the last four columns of the field blank. For example, February 8, 1970, would be coded as follows:

- | | | | |
|------------------------------------|----------|----|--------|
| 1. Full date is known: | 19700208 | or | 700208 |
| 2. Day of the month is not known: | 197002 | or | 7002 |
| 3. Month of the year is not known: | 1970 | or | 70 |

Time: The time of day is coded as a four-digit integer number consisting of two two-digit groups denoting (from left to right) the hours and minutes (HHMM) of a 24-hour clock. Each four-character time field or pair of (beginning and ending) time fields is preceded by a one-character field reserved for the appropriate one-letter U.S. Navy time zone designation (see below). In every case, the local zone time is to be used; in this manner ambiguities are avoided concerning the date, which is always assumed to be the "local" date (i.e., the date changes at local midnight).

Time Zone: A time zone is a geographic region in which uniform time differing by an integer number of hours from Greenwich Mean Time (GMT) is maintained by law. In theory, a time zone extends 7-1/2 degrees in longitude east and west of a "time meridian" whose longitude is a multiple of 15 degrees (since the Earth rotates 360 degrees in 24 hours, 15 degrees of longitude difference equals one hour of time difference). In practice, the lines which separate adjacent time zones often follow political boundaries and are therefore irregular. Associated with every time zone is a "time zone description" - an integer number positive west of Greenwich and negative east of Greenwich - which represents the number of hours which must be added (algebraically) to the local zone time in order to obtain the corresponding GMT. The time zone description is reduced by one hour when the standard zone time is changed to daylight-saving time.

Instead of the numeric time zone description, it is more convenient to use the U.S. Navy one-letter codes which uniquely identify each time zone. In this system, GMT is the "Z" (Zulu) Time Zone. Time zones east of Greenwich are identified by letters A, B, C, etc., through L, with the letter J omitted. Time zones west of Greenwich are identified by letters N, O, P, etc., through X. The letter Y is used to designate the western half of the time zone centered on the meridian of longitude 180 degrees (International Date Line), and the letter M is used to designate the eastern half of this zone.

The world-wide use of the time zone descriptions and the U.S. Navy one-letter designations is illustrated in ANNEX H. In the continental

United States, Alaska (AK), and Hawaii (HI) the time zones are as given in Table 6-3:

TABLE 6-3 - U.S. NAVY TIME ZONE DESIGNATIONS

<u>STANDARD TIME</u>	<u>DAYLIGHT TIME</u>	<u>TIME MERIDIAN</u>	<u>TIME ZONE DESCRIP'N</u>	<u>U.S. NAVY DESIGNATION</u>
Atlantic AST	Eastern EDT	60W	+4	Q (Quebec)
Eastern EST	Central CDT	75W	+5	R (Romeo)
Central CST	Mountain MDT	90W	+6	S (Sierra)
Mountain MST	Pacific PDT	105W	+7	T (Tango)
Pacific PST	Yukon YDT	120W	+8	U (Uniform)
Yukon YST	AK/HI HDT	135W	+9	V (Victor)
AK/HI HST	Bering BDT	150W	+10	W (Whiskey)

If the time zone cannot be reliably ascertained, leave the time zone field blank. In this case, the time given will be interpreted as the standard time in a zone determined on the basis of the longitude of the vertical control point from which the respective leveling observations (running) originate. As of this printing, Arizona, Hawaii, eastern Indiana, Puerto Rico, the Virgin Islands, and American Samoa do not observe daylight savings time. Verify locally (during the time of observations) whether or not daylight savings time is in effect.

SURVEY EQUIPMENT DATA RECORDS

- *20* Instrument Information Record
- *21* Rod Information Record
- *22* Rod Standardization Record
- *23* Rod Calibration Record

The survey equipment data records, identified by *20*-series data codes, are listed above; the block diagrams illustrating the respective formats are given in the FORMAT DIAGRAMS. The survey equipment data records contain identification and calibration data pertaining to the leveling instruments and rods used to carry out the differential leveling observations. See STRUCTURE OF THE VERT OBS DATA SET for the proper sequence in which the *20*-series records must appear in the block of records which constitutes a leveling line in a VERT OBS data set.

The *20* Instrument Information Record contains the data required to identify a leveling instrument (the appropriate NGS survey equipment code and the instrument serial number), date of stadia factor determination, and the stadia factor itself. This stadia factor will be used in the computation of the lengths of sights made with that instrument subsequent to the respective stadia factor determination date. Several *20* records may be submitted as a group for a leveling instrument; one for each past stadia factor determination.

The *21* Rod Information Record contains analogous data (the appropriate NGS survey equipment code and the rod serial number) required to identify a leveling rod; however, it does not contain any calibration data. Rod calibration data, which are required only for rods used in first- and second-order differential leveling work, must follow the *21* record in the form of a *22* record, a record set consisting of a *22* record and one or more *23* record(s), or a record set consisting of two or more *23* records, all bearing the same standardization/calibration date.

Again, several such *22* records, *22*, *23*,..., *23* record sets, and/or record sets of the form *23*, *23*,..., *23*, as appropriate, may be submitted as a group for a leveling rod following the respective *21* Rod Information Record; one such *22* record, *22*, *23*,..., *23* record set, or *23*, *23*,..., *23* record set for each past calibration of the leveling rod in question.

The *22* Rod Standardization Record contains the summary of a rod calibration. For the purposes of this chapter, the term "standardization" will be used to denote a group of data which is the end product of a rod calibration (i.e., the respective coefficient of thermal expansion, rod excess, and index error - see below). The *22* Rod Standardization Record may appear alone, or it may be followed by one or more *23* Rod Calibration Record(s) containing the (single-temperature) calibration data on which the standardization summary is based. Optionally, a *22* record may also precede a set of two or more *23* records of a multiple-temperature calibration; in this case, however, all data contained on the leading *22* record are inferable from the accompanying *23* records.

The *23* Rod Calibration Record contains data pertaining to the calibration of a leveling rod at one temperature. For single-temperature calibrations, submit one or more *23* record(s) following the corresponding *22* record (see above) - as many as required to accommodate all calibration intervals (three per *23* record - see FORMAT DIAGRAMS). For multiple-temperature calibrations, submit a set of *23* records (one or more per calibration temperature), with or without a preceding *22* record, which is optional in this case. In general, *23* Rod Calibration Records should be submitted whenever the respective data are available.

NGS Leveling Instrument and Rod File: The purpose of the *20*-series records is to provide input to a permanent computer file in which a historic record is maintained for each leveling instrument and leveling rod ever used in a VERT OBS data set submitted to the National Geodetic Survey. A record is established in this file for an instrument or rod at the first time it is encountered in the processing of a VERT OBS data set. Thereafter, the file is updated by adding new information to the respective instrument and/or rod records whenever

standardization or calibration data not previously available are encountered among the *20*-series records of a subsequently processed leveling line in the same or different VERT OBS data set.

Accordingly, it is not necessary to repeat identical *20* Instrument Information Records among the *20*-series records of every leveling line in which that instrument appears. It is sufficient, for any instrument, to submit one or more such records (one for each past determination of the respective stadia factor) once initially, and thereafter only when a new stadia factor is determined (e.g., following the installation of a new reticle). Of course, for each leveling line, care must be taken to insure that any omitted *20* Instrument Information Records have previously been made available for inclusion in the NGS Leveling Instrument and Rod File.

Analogously, it is not necessary to repeat identical *21* Rod Information Records, *22* Rod Standardization Records, and/or *23* Rod Calibration Records among the *20*-series records of every leveling line in which the respective rod appears. It is sufficient, for any rod, to submit an appropriate grouping of these records (covering all past calibrations) only once initially, and thereafter only when the leveling rod in question is recalibrated. Again, in connection with every leveling line, care must be taken to insure that any omitted *21*, *22*, and/or *23* records have previously been made available for inclusion in the NGS Leveling Instrument and Rod File.

To summarize, submit a *20* record for every previously unreported leveling instrument and/or previously unreported stadia factor determination. For every leveling rod, submit a *21* record alone if the rod has not previously been reported and no calibration data follow (e.g., a rod used in third- or lower-order differential leveling work exclusively). Otherwise, submit (as a group) one *21* record followed by one or more *22* records, one or more *22*, *23*,..., *23* record sets, and/or one or more *23*, *23*,..., *23* record sets, as appropriate; one such *22* record, *22*, *23*,..., *23* record set, or *23*, *23*,..., *23* record set for each previously unreported calibration of the leveling rod in question.

NGS Survey Equipment Code: A three-digit numeric identification code assigned to each category of survey equipment, and within each category to specific instruments or other commonly used items. In particular, leveling instruments are assigned 200-series survey equipment codes, while leveling rods and staves are assigned 300-series survey equipment codes (see ANNEX F).

Instrument/Rod Serial Number: Assigned by the manufacturer, the serial number is the ultimate identifier of a specific leveling instrument or leveling rod. Serial numbers are normally numeric;

however, alphabetic characters are often used as prefixes, suffixes, etc., and special characters such as a blank (space), hyphen (minus sign), slash (solidus), etc., may appear imbedded in the respective alphanumeric character group. For this reason, a serial number must be treated as alphanumeric information to be entered in the respective character field left-justified and blank-filled on the right.

The instrument or rod serial number will be used together with the respective survey equipment code (see above) to create appropriate entries in the NGS Leveling Instrument and Rod File, to maintain these entries up to date, and to access this file for the retrieval of the respective stadia factor and/or rod calibration data in the course of routine processing of VERT OBS data sets. It is therefore of utmost importance that the respective serial number be faithfully reproduced as given by the manufacturer, character for character, including any leading zeros, imbedded blanks, etc., and that identical serial number representation be used consistently whenever reference is made to that specific instrument or rod in any VERT OBS data set.

Stadia Factor: An instrument-specific constant numerically equal to the ratio of the focal length of the instrument to the respective stadia interval, i.e., to the distance which separates the stadia lines (two horizontal lines spaced equally above and below the level line) in the reticle of the leveling instrument. By design, the stadia interval is chosen so that the stadia factor is a convenient integer number such as 100.

The stadia factor is used to obtain the distance between the leveling instrument and a rod as the product of the stadia factor multiplied by the respective (full) stadia intercept - see OBSERVATION DATA RECORDS. Note that a sight length so obtained is in the same units as the stadia intercept, i.e., in rod units, and hence must be further multiplied by a conversion factor to obtain the sight length in other units.

Rod Units: The units in which the respective rod scale is graduated. Four different rod units are acceptable, each identified by a two-letter code. They are as follows:

CF - centifeet (0.01 ft)
CM - centimeters (0.01 m = 1 cm)
CY - centiyards (0.01 yd = 0.03 ft)
HC - half-centimeters (0.005 m = 0.5 cm = 5 mm)

Rod Graduation Code: A one-digit code denoting the type of graduation of the respective leveling rod:

1 - line graduation (single scale)
2 - line graduation (double scale)
3 - block graduation (including checkerboard)
4 - other

Temperature Scale: The temperature at which the leveling rod was calibrated must be given on both the *22* Rod Standardization Record (Standardization Temperature) and the *23* Rod Calibration Record (Calibration Temperature). On either record, provision is made to indicate which of the two possible temperature scales applies by means of a one-letter code immediately preceding the respective temperature field:

- C - Celsius Temperature Scale
- F - Fahrenheit Temperature Scale

Coefficient of Expansion: The relative change in linear dimension (expansion or contraction) per unit of temperature change peculiar to the material of the respective leveling rod scale (these include INVAR or other low-expansion metal alloys for modern rods, and specially treated wood for rods used in older differential leveling work of high precision). Aside from the scale factor 10,000 mentioned below, the coefficient of expansion given on the *22* Rod Standardization Record must be in units which are compatible with the respective temperature scale and rod units (see above), as specified in Table 6-4.

TABLE 6-4
UNITS OF COEFFICIENT OF EXPANSION

ROD UNITS	TEMPERATURE SCALE	
	C	F
CF	feet per degree Celsius	feet per degree Fahrenheit
CM	meters per degree Celsius	meters per degree Fahrenheit
CY	feet per degree Celsius	feet per degree Fahrenheit
HC	meters per degree Celsius	meters per degree Fahrenheit

The coefficient of expansion expressed in either one of the four possible unit combinations (see above) is always a very small decimal fraction. To avoid the keying of a long string of zeros preceding the first significant digit, enter the respective coefficient of expansion multiplied by 10,000, i.e., with the decimal point moved four places to the right (Example: A coefficient of expansion of 0.00000079 is entered as 0.0079 or .0079).

A-Flag: Enter 'A' if the coefficient of expansion (see above) is an "assumed" value (i.e., as given by the manufacturer, or a standard value for the material in question). Leave the field blank if the coefficient of expansion has been determined by means of a multiple-temperature calibration of the respective leveling rod.

Rod Excess: A factor used to compute the rod correction for a single running of a section of a leveling line. The rod calibration process precisely determines the actual length of the respective rod (or of a representative segment thereof). Rod excess is the ratio of the difference between the actual and nominal length (actual minus nominal) to the nominal length of the rod (or calibrated segment thereof).

Note that the rod excess is a unitless number; however, since it is always a small (positive or negative) decimal fraction, it is convenient to express rod excess as the aforementioned ratio multiplied by 1,000 (i.e., as millimeters per meter, if metric units are being used). Accordingly, regardless of the respective rod units, enter the rod excess with the decimal point moved three places to the right.

Index Error: The distance above or below the bottom surface (foot) of the leveling rod at which the nominal origin (zero) of the respective graduated scale is located (the origin of the low scale of a rod with a double-scale graduation). The index error is positive when the scale origin falls below the foot of the rod; it is negative when the scale origin falls above the foot of the rod. Note that the index error is expressed in rod units (see above) of the leveling rod in question.

FIELD ABSTRACT DATA RECORDS

30 Field Abstract Record

The purpose of the *30* record is to provide cross-reference between the primary identifier (i.e., the designation) of a vertical control point and the corresponding job-specific survey point serial number (SPSN). In addition, the accumulated distance along the leveling line and the respective "field" elevation (see below) are given on this record. Following established practice, these latter two data items are computed from the detailed differential leveling field notes as the work progresses and are normally recorded on a form called the "Field Abstract" - hence the name "Field Abstract Record." The block diagram illustrating the respective format will be found with the FORMAT DIAGRAMS.

Submit a *30* record for the first (starting) survey point (bench mark or temporary bench mark), followed by a *30* record for each elevation carried forward to a survey point by the differential leveling process. Normally, in the absence of any closed loops, there will be as many

30 records as there are survey points along the leveling line. However, if a loop is closed (as in the case of a spur loop or if the line itself forms a closed loop), an additional *30* record must appear in proper sequence (see below) for the endpoint of each such loop, reflecting the elevation carried forward to that bench mark or temporary bench mark via the loop.

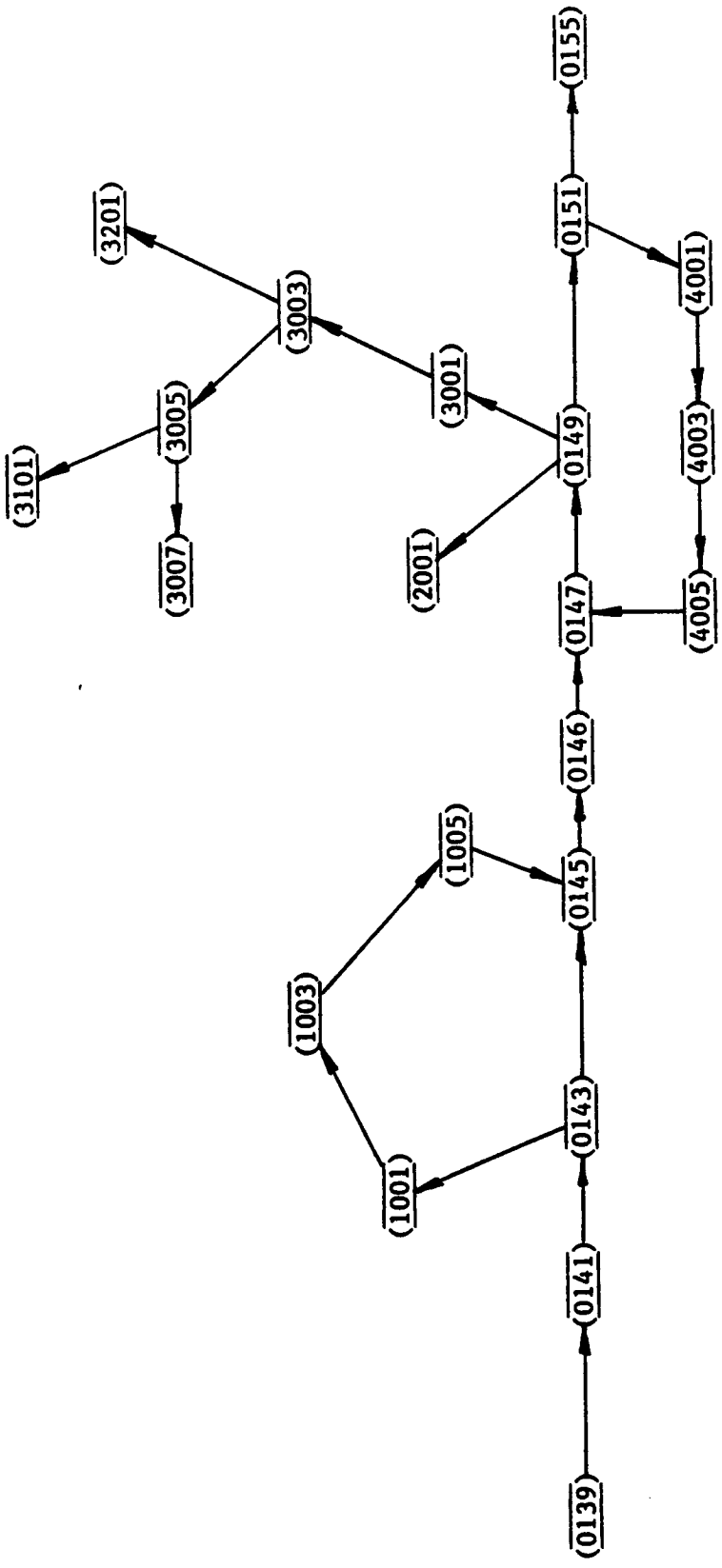
Order of the *30* Records: As was previously covered in the section on the STRUCTURE OF THE VERT OBS DATA SET, the order of the *30* records is crucial. This is because the *30* records, as a group, define the leveling line in question, i.e., they define the nominal sequence of bench marks and temporary bench marks along the leveling line.

Normally, the *30* records should follow the same sequence as the respective survey points occur along the leveling line. However, one or more spurs may emanate from any survey point - in which case, after the *30* record for such a "base" point, the *30* records for all survey points along the longest spur must follow first, then those along the next-longest spur, etc. Only when all spurs emanating from that base point have thus been exhausted should the *30* record for the elevation carried forward to the next survey point along the main route of the leveling line be given - see example in Figure 6-1.

Survey Point Serial Number: For the purpose of identifying the initial and terminal points of each section of the leveling line in a concise and unique manner (e.g., on the respective *41* and *42* records - see OBSERVATION DATA RECORDS), each survey point that is leveled to in a vertical control job (bench mark or temporary bench mark) is assigned a job-specific serial number in the range 0001 to 9999. All survey points for which recovery descriptions are written, but which were not leveled to in the current project, are to be assigned the SPSN code 0000. See Chapter 5 for a detailed explanation of the survey point numbering system.

The survey point serial number (SPSN) is also used in the correlation of the data pertaining to the bench marks and temporary bench marks which appear in the VERT OBS data set with the corresponding descriptive data contained in the companion VERT DESC data set of the vertical control job. For this reason, special care must be taken to insure that the identical survey point serial number assigned to a bench mark or temporary bench mark in the VERT OBS data set is also used to identify the same survey point in the respective companion VERT DESC data set.

Designation: A vertical control point or bench mark is normally identified by a numeric or alphanumeric symbol which is stamped on the disk marker (or is otherwise inscribed on the bench mark monument) to which is appended the abbreviation or acronym (see Annex C) of the agency whose name is precast in the monument - if other than the



Sequence of the *30* Records:

1. 0139
2. 0141
3. 0143
4. 1001
5. 1003
6. 1005
7. 0145
8. 0145
9. 0146
10. 0147
11. 0149
12. 3001
13. 3003
14. 3005
15. 3101
16. 3007
17. 3201
18. 2001
19. 0151
20. 4001
21. 4003
22. 4005
23. 0147
24. 0155

FIGURE 6-1 - Example of Field Abstract Record sequence.

National Geodetic Survey, National Ocean Survey, or Coast and Geodetic Survey (see Origin). For marks not having a precast agency name, append the acronym or abbreviation of the agency which set the mark (see Setting-by-Agency). If the agency cannot be determined, do not append an agency acronym or abbreviation. Less frequently, a bench mark is assigned a concise, intelligible name (e.g., when a horizontal control point also becomes a bench mark); the appropriate acronym or abbreviation should be appended to these also. A maximum of 25 characters (including all imbedded blanks) is allowed.

In every case, the bench mark designation entered on the *30* record must be identical to the (primary) designation used to identify the same vertical control point in the companion VERT DESC data set of the vertical control job - refer to Chapter 7. Use the same general guidelines for the designations of any survey points which lack descriptive data (e.g., undescribed temporary bench marks which may have to be carried in the VERT OBS data set but which do not appear in the companion VERT DESC data set).

Accumulated Distance: The distance covered by the differential leveling operation from the nominal starting point of the leveling line to the survey point in question. It is obtained by successively adding the lengths of the intervening sections (following the line-order conventions used for the ordering of the *30* records in the case of a survey point located on a spur or leveled to via a spur loop - see Order of the *30* Records). Recall that "section" is a segment of the leveling line consisting of two neighboring survey points connected by a chain of differential leveling observations (i.e., connected by a "running").

The individual section lengths are obtained by accumulating the lengths of the backsight and foresight of each setup of the respective running, which in turn are usually obtained as a function of the corresponding stadia intercepts (see Stadia under OBSERVATION DATA RECORDS) and the stadia factor of the leveling instrument used. For this purpose, use the minimum section length if more than one running has been made over a section, as is the normal case.

The accumulated distance (as well as the field elevation - see below) is carried on the *30* record to provide a check against certain undetected keying errors, line order errors, errors in the assignment of survey point serial numbers, etc. For this reason, the accumulated distance entered in this field must be the value which is normally computed and "abstracted" in the course of the differential leveling operation. In particular, the accumulated distance must not be generated (e.g., by software) from the respective *41* and *42* records (see OBSERVATION DATA RECORDS), as this would defeat the purpose for which it is intended.

Field Elevation: The approximate elevation of the survey point in question is obtained as the (algebraic) sum of the elevation of the starting point of the leveling line and the raw (i.e., uncorrected) elevation differences determined for the intervening sections (following the line-order conventions used for the ordering of the *30* records in the case of a survey point located on a spur or leveled to via a spur loop - see Order of the *30* Records). (Recall that a "section" is a segment of the leveling line consisting of two neighboring survey points connected by a chain of differential leveling observations referred to as a "running.")

The end product of every running over a section of the leveling line is the respective observed, uncorrected elevation difference (see Elevation Difference under OBSERVATION DATA RECORDS). When more than one running has been made over a section, as is the normal case, a "section mean" must be computed using all forward and backward runnings made over that section which have passed appropriate field rejection criteria.

Noting that a backward running produces an elevation difference of opposite sign, the respective section mean is defined as the algebraic difference between the sum of elevation differences determined by forward runnings and the sum of elevation differences determined by backward runnings divided by the number of runnings. In other words, if ΣF is the sum of all acceptable forward-running elevation differences, and ΣB is the sum of all acceptable backward-running elevation differences, the desired section mean is $(\Sigma F - \Sigma B)/n$, where n is the number of runnings.

The field elevation (as well as the accumulated distance - see above) is carried on the *30* record to provide a check against certain undetected keying errors, line order errors, errors in the assignment of survey point serial numbers, etc. For this reason, the field elevation entered in this field must be the value which is normally computed and "abstracted" in the course of the differential leveling operation. In particular, the field elevation must not be generated (e.g., by software) from the respective *41* and *42* records (see OBSERVATION DATA RECORDS), as this would defeat the purpose for which it is intended.

OBSERVATION DATA RECORDS

- *40* Survey Equipment Record
- *41* Running Record
- *42* River/Valley Crossing Record
- *43* Correction/Rejection Record

The observation data records, identified by *40*-series data codes, are listed above; the block diagrams illustrating the respective formats are given in the FORMAT DIAGRAMS. The purpose of the *40*-series

records is to provide the means to record the differential leveling observations carried out along a leveling line. Recall that a leveling line is a unit of field work consisting of a number of survey points (bench marks and temporary bench marks) connected by differential leveling observations, and that "section" is a segment of the leveling line consisting of two neighboring survey points which are connected by one or more differential leveling observations.

The differential leveling observations carried out over a section of leveling line are of two basic types - runnings and crossings - see below.

Normally, the (observed) elevation difference between the endpoints of a section is determined as the accumulation of a continuous series of small elevation difference measurements, each obtained as the difference between the respective backsight and foresight readings on a pair of leveling rods positioned vertically over "turning points" at a relatively short sight distance from the leveling instrument. This type of differential leveling observation which consists of a chain of small elevation difference measurements (i.e., leveling instrument "setups") is called a "running."

When carried out in the nominal direction of progress of the leveling line, it is called a "forward" running; when carried out in the opposite direction, it is called a "backward" running. A section which is "double-run" (as is the normal case) will have at least one forward and one backward running (among possibly several runnings in either direction) which meet field acceptance criteria (i.e., the disagreement between the respective observed elevation differences does not exceed the tolerance which is in effect for the order and class of the vertical survey in question).

Submit a *41* record for every running carried out along the leveling line, regardless of its field acceptance or rejection status (rejected runnings may be brought within the respective tolerance after various corrections are applied in the course of subsequent data processing). The *41* records must be submitted in sets consisting of a *40* record followed by one or more *41* records - one for each running made on the same date, using the same leveling instrument and the same leveling rods, and subject to the same level collimation error (see below) as specified in the respective leading *40* record - see STRUCTURE OF THE VERT OBS DATA SET.

The other type of differential leveling observation is the "river/valley crossing" (or "crossing") which is used when a gap larger than the maximum allowable sight length of a setup must be spanned, as when a river (or dry canyon) must be crossed without using a suitable bridge. This type of differential leveling observation is the result of a series of reciprocal measurements carried out simultaneously from both sides of

such a gap using special "valley-crossing" equipment. Note that each individual river/valley crossing must be treated as a separate section of the leveling line.

Submit a *42* record for every river/valley crossing along the leveling line. The *42* records, if any, must appear as the last group of records of the respective leveling line block in the VERT OBS data set (see STRUCTURE OF THE VERT OBS DATA SET).

Submit a *43* record for each running or river/valley crossing for which a refraction correction was determined from temperature profile measurements made by field personnel, or for which a rod correction was determined using detailed rod calibrations furnished by the National Bureau of Standards. Also, if a running or river/valley crossing was rejected, include a *43* record indicating the source of the rejection (field or office). Each required *43* record should immediately follow its corresponding *41* or *42* record. If temperatures were observed only at the upper- and lower-temperature probes, leave the columns labeled "Mean temperature for middle probe" and "Height of middle probe" blank. The columns labeled "Rod Correction in mm" refer to values determined using "detailed" rod calibrations (the calibration of all rod graduations) furnished by the National Bureau of Standards. *

Level Collimation Error: The (small) angle by which the line of sight defined by the center of the crosslines in the reticle and the optical center of the objective lens of a leveling instrument departs from the horizontal when the instrument is "level": positive when the line of sight deviates upward, and negative when the line of sight deviates downward from horizontal. The collimation error is due to a small misalignment between the respective bubble vial (in the case of spirit-level instruments) or compensator mechanism (in the case of self-aligning instruments) and the line of sight (line of collimation).

The level collimation error can be resolved into two components--a residual constant component (which can be minimized by careful adjustment of the instrument) and a variable component which is caused by transient deformation of the structural parts of the instrument brought about by stresses and strains due to uneven temperature distribution (differential heating) and other intermittent physical forces which are active in the course of the daily handling of the leveling instrument.

Because of the unpredictable nature of the intermittent component, the level of collimation error must be determined at sufficiently frequent intervals to permit the application of meaningful corrections to the respective leveling rod readings. Note that the effect of the collimation error cancels for a setup with backsight and foresight of equal length; it is the total accumulated length imbalance between all the backsights and foresights of a running to which the correction for collimation error is applicable.

Tangent of Collimation Error: The observing procedure by means of which the collimation error is determined (commonly known as the "C-Test") produces the ratio of the corresponding rod reading error to the length of line of sight, i.e., the trigonometric function tangent of the collimation error.

Note that the tangent of an angle is a unitless number; however, since it is a very small (positive or negative) decimal fraction, it is convenient to use the tangent of collimation error multiplied by 1000 (i.e., as millimeters per meter, if the metric units are being used). Accordingly, enter the tangent of collimation error with the decimal point moved three places to the right.

Wind Code: A one-character numeric code, the purpose of which is to denote the approximate wind conditions prevailing during the course of the running. The three wind codes are:

- 0 - wind speed less than 10 kilometers per hour
- 1 - wind speed from 10 to 25 kilometers per hour
- 2 - wind speed greater than 25 kilometers per hour

Sun Code: A one-character numeric code, the purpose of which is to denote the approximate conditions of insolation prevailing during the course of the running. The three sun codes are:

- 0 - less than 25% of setups under sunny conditions
- 1 - 25% to 75% of setups under sunny conditions
- 2 - more than 75% of setups under sunny conditions

Stadia, Stadia Intercept, and Stadia Intercept Code: Stadia is a method of obtaining the approximate distance (typically to the nearest 0.1 meter) between the leveling instrument and a vertically positioned leveling rod as the product of the instrument's stadia factor (as specified in the corresponding *20* record) and the respective stadia intercept - the difference between the high and low stadia line readings on the respective rod. Recall that stadia lines are two horizontal lines spaced equally above and below the horizontal crossline in the reticle of the leveling instrument. Note that the distance obtained in this manner is in the same units as the stadia intercept, i.e., in rod units of the respective leveling rod (as specified in the corresponding *21* record).

For differential leveling observations, stadia information is desired (1) to compute the total length of the running, and (2) to compute the total accumulated length imbalance between the backsights and foresights of the running (to eliminate the residual effect of collimation error - see Level Collimation Error above). Because of the latter requirement, two fields are provided for the entry of stadia information, one for the Sum of Backsight Stadia Intercepts and the other for the Sum of Foresight Stadia Intercepts.

As was mentioned previously, the two stadia lines are equidistant from the horizontal crossline (level line) of the leveling instrument. The use of full stadia intercepts requires the observation and recording of two rod readings (the stadia high and the stadia low readings) in

addition to the level line reading. It is possible to observe only one stadia line reading (either the stadia high or the stadia low) in addition to the level line reading, in which case half stadia intercepts are obtained. Note that either full stadia intercepts or half intercepts must be observed consistently throughout a running. To specify which one of the two possible procedures has been followed, provision is made on the *41* record for a one-letter Stadia Intercept Code:

F - full stadia intercepts observed
H - half stadia intercepts observed

Units: A set of two-letter codes for the various units of length in which the length of running (*41* record), length of crossing (*42* record), and elevation difference (*41* and *42* records) may be given. It is the same set of unit codes which is used on the *30* record to denote the units of accumulated distance and field elevation - see FIELD ABSTRACT DATA RECORDS. The specific unit codes are:

MT - meters	KM - kilometers
FT - feet	KF - kilofeet
YD - yards	SM - statute miles

Running Length: The overall length of the running (i.e., the distance covered by the differential leveling observations), preceded by the respective units code, only if the stadia information (see above) is not available; otherwise leave blank.

Crossing Length: Enter the overall length of the crossing (i.e., the distance spanned by the river/valley crossing observations), preceded by the respective units code.

Elevation Difference: Enter the observed difference of elevation as determined by the running or crossing in question, preceded by the respective units code. Note that this must be the raw observed elevation difference, i.e., the result of the running or crossing observations to which no corrections have been applied.

FORMAT DIAGRAMS

For each record which appears in a VERT OBS data set (see Table 6-1), a block diagram has been prepared to illustrate the respective format. These "format diagrams" have been designed to fulfill the following objectives:

1. Each record is 80 characters long (standard punched card image).
2. Each record has a fixed format, i.e., every data field has a specific length and specific position within the record.

3. Each format diagram is a graphic image of the respective record.
4. Within the limits of available space, information and instructions concerning the data item to be entered in each data field are provided on the format diagrams to render them self-explanatory.
5. When appropriate, sample entries are shown in the data entry line of each format diagram.
6. Each data field is characterized as to its type by a string of lower-case characters which appear immediately below the data entry line.

Data Field Types:

1. Alpha Field (aa...a) - intended for a data item which is coded as a string of alphabetic, numeric, and/or special characters, with or without imbedded blanks, to be entered into the respective data field left-justified and blank-filled on the right. See Chapter 5 for a list of special characters which are allowed.
2. Blank Field (bb...b) - to be blank-filled. Data fields which are designated as blank fields must be left blank, i.e., no data items may be entered in these fields.
3. Constant (Numeric) Field (cc...c) - intended for a data item which is a number (i.e., an integer, a proper or improper fraction, or a decimal fraction) coded as a string of numeric characters (prefixed with a minus sign if the number is negative) which may contain one leading or imbedded (but not trailing) decimal point if it is a decimal fraction, or an imbedded hyphen and/or slash if it is a proper or improper (mixed) fraction such as 3/4, 5-1/2, etc., to be entered into the respective data field left-justified and blank-filled on the right.
4. Floating-Point Field (ff...fdd...d) - intended for a data item which is coded as a decimal number, i.e., as a string of numeric characters (prefixed with a minus sign if the number is negative) which may not contain any imbedded blanks. If the decimal point is present, the character string representing the integer digits, the decimal point, and the decimal fraction digits may be positioned anywhere within the respective field (generally left-justified), and the unused columns of the data field are blank-filled.

When the decimal point is not coded, the "f" portion of the floating-point field is to contain the integer part of the decimal number, and the "d" portion the corresponding decimal fraction part,

the decimal point being implied between the rightmost "f" column and the leftmost "d" column of the field.

Accordingly, a string of numeric characters representing m integer digits followed by n decimal fraction digits with the decimal point absent must be positioned in the floating-point field in such a manner that its integer part falls into the m rightmost "f" columns, and its decimal fraction part into the n leftmost "d" columns, with any unused columns of the data field being blank-filled. When a negative number is entered, code the minus sign immediately preceding the leading digit.

5. Integer Field (ii...i) - intended for a data item which is coded as a string of numeric characters representing a positive or negative integer number, to be entered into the respective data field right-justified. In the case of a positive integer number, zero-fill any unused columns on the left. In the case of a negative integer number, code the minus sign immediately preceding the leftmost non-zero digit, and blank-fill any unused columns to the left of the minus sign.

6. Specific Character Field (ss...s) - intended to contain a specific alphabetic, numeric, special character, or a specific group of characters. Every "s" column of a specific character field must contain the character shown in that position in the data line of the respective format diagram.

Required Data: In general, only those records which are applicable to the data at hand should be included in a VERT OBS data set (e.g., no *42* records need be submitted if there are no river/valley crossings along the respective leveling line). The character fields intended for data items which are essential have been shaded on the format diagrams; if applicable to the data being coded, these character fields must be in accordance with the instructions given on the respective format diagrams or in the text of this chapter. Records which are optional or those which may be omitted under certain circumstances are clearly designated in the headings, footnotes, or bodies of the corresponding format diagrams.

11 Line Title Record (Optional) and *12*, *13*, *14* Line Title Continuation Records (Optional).
 Use the *11* record to give the title of the line (or of area network or special project of which the line is a part) and the *12*, *13*, *14* records for continuation and/or subtitles, if any.

000000001111111122222222333333334444444455555555666666667777777788888888
 1234567890123456789012345678901234567890123456789012345678901234567890

Line Title - use *12*, *13*, *14* Line Title Continuation Record(s) as required if the title exceeds 70 characters or if subtitles are necessary (e.g. the title of an area network followed by title of the line).

The title of a leveling line should be descriptive of the route followed, i.e., it should indicate the starting and ending locations and prominent "via" points, if any (Example: ALBANY GA VIA MORVEN TO CALLAHAN FL).

Do not divide words (or other character groups) between the *11*, *12*, *13*, *14* Line Title and Line Title Continuation Records. Omit punctuation marks (periods, commas, etc.) and parentheses whenever possible. Use ANNEX A state and country codes whenever reference to a state or country is necessary.

Abbreviate and/or edit a line title in the interest of fitting the entire title on the *11* Line Title Record, if possible.

Data Code
 (*11*, *12*, *13*, *14* Line Title Records)

Sequence Number
 Increment by 10 on successive records to allow for insertions.

000000001111111122222222333333334444444455555555666666667777777788888888
 1234567890123456789012345678901234567890123456789012345678901234567890

000000001111111122222222333333334444444455555555666666667777777788888888
 1234567890123456789012345678901234567890123456789012345678901234567890

000000001111111122222222333333334444444455555555666666667777777788888888
 1234567890123456789012345678901234567890123456789012345678901234567890

***30* Field Abstract Record.** Submit this record for the first (starting) survey point (bench mark or temporary bench mark) and thereafter for each elevation carried forward (possibly more than once for any given survey point) in the order of occurrence along the leveling line - see text.

0000000011111111222222223333333344444444555555566666667777777888888899001234567890123456789012345678901234567890	<p>Important: Data items hereunder must be keyed from the Field Abstract and not generated from the respective *41*/*42* records - see text.</p>
<p><u>Designation</u> - must not exceed 25 characters.</p> <p>This is the primary designation which will be associated with the vertical control point for publication purposes. In every case, the designation must be edited in conformity with <u>Guidelines for Survey Point Names and Designations</u> (ANNEX D).</p> <p>The designation entered in this field must be identical (character for character) with the designation given for the same point in the corresponding VERT DESC data set.</p>	<p><u>Field Elevation</u> - see text. Enter left-justified and key the decimal point. Prefix minus sign if applicable.</p> <p><u>Units</u> - MT, FT, or YD.</p>
<p><u>Survey Point Serial Number (SPSN)</u> - see Chapter 5. Must be same as SPSN used in VERT DESC data set.</p>	<p><u>Accumulated Distance</u> - see text. Enter left-justified and key the decimal point.</p> <p><u>Units</u> - see footnote.</p>
<p><u>Data Code</u> (*30* - Field Abstract Record)</p>	<p><u>Field Elevation</u></p>
<p><u>Sequence Number</u> Increment by 10 on successive records to allow for insertions.</p>	<p><u>Accumulated Distance</u></p>
<p>0000000011111111222222223333333344444444555555566666667777777888888899001234567890123456789012345678901234567890</p>	<p>0000000011111111222222223333333344444444555555566666667777777888888899001234567890123456789012345678901234567890</p>

Units: MT - meters FT - feet YD - yards
 KM - kilometers KF - kilofeet SM - statute miles

41 Running Record. Submit this record for every running other than river/valley crossing. The *41* records for all runnings made on the same date, using the same equipment, to which the same collimation error applies must follow, as a group, immediately behind the respective *40* record.

0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Initials of the Observer - left-justified.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Elevation Difference - observed, uncorrected elevation difference determined by the running.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Elevation Difference - in the units indicated, left-justified.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Units - MT, FT, or YD.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Length of Running - if stadia data unavailable; leave blank otherwise.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Length of Running - in the units indicated, left-justified.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Units - see *30* record
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Stadia - enter to the nearest 0.1 of the respective rod unit.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Note implied decimal point.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Sum of Foresight Stadia Intercepts
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Sum of Backsight Stadia Intercepts
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Stadia Intercept Code - F-full, H-half.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Number of Setups in the running.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Wind and Sun Codes - see footnotes.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Temperature of Air
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Temperature at ending time and place - left-justified.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Temperature at starting time and place - left-justified.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Scale - C-Celsius, F-Fahrenheit.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Ending Time of running.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Starting Time of running.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Time Zone - see ANNEX H.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Ending Survey Point Serial Number (SPSN) - must be same as SPSN on the corresponding *30* record.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Starting Survey Point Serial Number (SPSN) - must be same as SPSN on the corresponding *30* record.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Date of Running - year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Data Code (*41* - Running Record)
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Sequence Number
0000000001	11111111	11111111	22222333	33333333	44444444	55555555	66666666	77777777	777890	Increment by 10 on successive records to allow for insertions.

Wind Code: 0 - less than 10 km/hour, 1 - 10-25 km/hour, 2 - more than 25 km/hour wind speed.
 Sun Code: 0 - less than 25%, 1 - 25-75%, 2 - more than 75% of setups under sunny conditions.

43 Correction/Rejection Record. Submit this record for each running or river/valley crossing when 1) temperature profiles were measured in the field, 2) a rod correction can be determined using detailed rod calibrations furnished by the National Bureau of Standards, or 3) the running or river/valley crossing is to be rejected.

00000000	11111111	22222222	33333333	44444444	55555555	66666666	77777777	88888888	99999999
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
<u>Sequence Number</u> Increment by 10 on successive records to allow for insertions.									
<u>Data Code</u> - preceded and followed by asterisk (*43* - Correction/Rejection Record)									
<u>Date of Running or River/Valley Crossing</u> - year, month, day (YYMMDD)									
<u>Starting Survey Point Serial Number (SPSN)</u>									
<u>Ending Survey Point Serial Number (SPSN)</u>									
<u>Starting Time of Running or River/Valley Crossing</u>									
<u>Refraction Correction in mm.</u> Enter left-justified and key the decimal point.									
<u>Field/Office Rejection</u> - see note above.									
<u>Rod Correction in mm.</u> Enter left-justified and key the decimal point.									
<u>Temperature scale C - Celsius F - Fahrenheit</u>									
<u>Mean temperature for upper probe.</u> Enter left-justified and key the decimal point.									
<u>Mean temperature for lower probe.</u> Enter left-justified and key the decimal point.									
<u>Mean temperature for middle probe.</u> Enter left-justified and key the decimal point.									
<u>Temperature Code.</u> O-Observed, P-Predicted.									
<u>Note - Field/Office Rejection Codes:</u> F = Field rejection O = Office rejection % = not rejected									

Data Set Termination Record. This must be the last record of every data set submitted.

00000000111111112222222233333333444444445555555566666666777777778888888899999999 123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890	<p>Data Set Structure: A VERT OBS Data Set consists of one or more leveling lines.</p> <table border="1" style="width: 100%;"> <tr> <th colspan="2">Data Set Identification Record</th> </tr> <tr> <td style="width: 70%;">*10*-series records</td> <td rowspan="4" style="text-align: center; vertical-align: middle;">FIRST LINE</td> </tr> <tr> <td>*20*-series records (if any)</td> </tr> <tr> <td>*30* records</td> </tr> <tr> <td>*40*-series records</td> </tr> <tr> <td>*10*-series records</td> <td rowspan="4" style="text-align: center; vertical-align: middle;">SECOND LINE</td> </tr> <tr> <td>*20*-series records (if any)</td> </tr> <tr> <td>*30* records</td> </tr> <tr> <td>*40*-series records</td> </tr> <tr> <td style="text-align: center;">:::</td> <td style="text-align: center;">:::</td> </tr> <tr> <td style="text-align: center;">:::</td> <td style="text-align: center;">:::</td> </tr> <tr> <td>*10*-series records</td> <td rowspan="4" style="text-align: center; vertical-align: middle;">LAST LINE</td> </tr> <tr> <td>*20*-series records (if any)</td> </tr> <tr> <td>*30* records</td> </tr> <tr> <td>*40*-series records</td> </tr> <tr> <th colspan="2">Data Set Termination Record</th> </tr> </table>	Data Set Identification Record		*10*-series records	FIRST LINE	*20*-series records (if any)	*30* records	*40*-series records	*10*-series records	SECOND LINE	*20*-series records (if any)	*30* records	*40*-series records	:::	:::	:::	:::	*10*-series records	LAST LINE	*20*-series records (if any)	*30* records	*40*-series records	Data Set Termination Record		111111112222222233333333444444445555555566666666777777778888888899999999 1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
Data Set Identification Record																									
10-series records	FIRST LINE																								
20-series records (if any)																									
30 records																									
40-series records																									
10-series records	SECOND LINE																								
20-series records (if any)																									
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00000000111111112222222233333333444444445555555566666666777777778888888899999999 1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890	<p><u>Sequence Number</u> Increment by 10 on successive records to allow for insertions.</p>	111111112222222233333333444444445555555566666666777777778888888899999999 1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890																							