Chapter 1

HORIZONTAL CONTROL (HZTL) DATA

INTRODUCTION

For coding and processing purposes, data associated with geodetic horizontal control (HZTL data) have been divided into two groups. These are (1) field observations (OBS data) and (2) descriptions and recovery notes (DESC data). Instructions and formats for coding and typing HZTL OBS and DESC data sets are contained in Chapter 2 and Annex P. The treatment of all data normally generated in the conduct of a classical or GPS horizontal control survey is described.

Although both types of data are normally generated in a horizontal control survey, OBS and DESC data must be submitted to NGS in separate data sets. These will be inserted into the National Geodetic Survey Data Base. The foregoing implies that every horizontal control survey project (or several small projects submitted as one "job" - see below) will be received at NGS as two distinct data sets HZTL OBS and DESC data sets. The two data sets created for each horizontal control job must be submitted at the same time.

JOB CODE AND SURVEY POINT NUMBERING

The basic unit or group of data is given the name "job." A horizontal control job can contain the data for a maximum of 9999 survey points - see the definition of "survey point" below. If the number of survey points in a horizontal control survey project exceeds this limit, the data must be divided and submitted in multiple jobs. A job will normally contain the data collected for one project (i.e., one unit of field work); however, several small projects can be included in one job, even though they may have no points in common. The preferred determining factor in selecting several small horizontal control survey projects for inclusion in any one job is geographic proximity.

A two-character alphanumeric job code must be assigned to each horizontal control job submitted by an organization. The job code, along with the data set type, the name of the submitting agency, and the data set creation date will serve to uniquely identify each 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). The preferred method of assigning job codes is to begin with Al and end with ZZ, i.e., Al, A2, ..., A9, Bl, ..., Zl, ..., Z9, AA, AB, ..., ZZ. This allows for a total of 910 uniquely-identified horizontal control jobs to be submitted by any one organization. Should this sequence be exhausted, the job codes may then be assigned again from the beginning - Al, A2, etc.

A horizontal control point is defined as any survey point whose position has been previously determined and is in the NGS Data Base, whose position is to be determined in an adjustment of the submitted HZTL OBS data, or whose (adjusted) position is available from another source. A survey point is defined as any point which has one or more directions, angles (horizontal or vertical), distances or vectors measured to it or from it. A survey point may be a monumented (or otherwise permanently marked) control point, a reference mark or azimuth mark, a temporary point (not permanently marked and therefore non- recoverable) such as an auxiliary point, or an unmonumented recoverable landmark (usually an intersection station) such as a flagpole or church spire. An eccentric instrument setup and eccentric target (or reflector) also qualify as survey points under this definition.

Each survey point in a horizontal control job must be assigned a unique four-digit station serial number (SSN) within the range 0001 through 9999. The SSN not only identifies the various observations within the HZTL OBS data set but is the project-specific link between data in the HZTL OBS data set and data in the DESC data set.

Normally there are many survey points in a horizontal control job which are not intended as control points. These points are, by their nature, peripheral to a control point. Examples of peripheral points are unoccupied reference and azimuth marks. Eccentric instrument setups and eccentric targets (or reflectors) are treated as peripheral points if the respective eccentric observations are to be reduced to center. This is usually the case when the eccentric point is not permanently marked. But, if an eccentric point is offset more than 10 meters from the control point to which it belongs (even though it may be unmarked), or if the eccentric point is permanently marked (e.g., a reference mark is occupied), then the respective eccentric observations should not be reduced to center, and the eccentric point should be treated as another control point.

When an eccentric instrument setup is utilized in a field project, whose offset distance from the respective control point does not exceed 10 meters, the respective eccentric observations should be reduced to center by the submitting organization and coded in the HZTL OBS deck as if the control station had been occupied. If for any reason this is not desired, the eccentric point in question must be carried as a control point and assigned its own SSN.

An unoccupied reference or azimuth mark has one or more directions, angles, and/or distances measured to it but not from it. A reference mark or azimuth mark which is occupied as a part of the survey scheme (e.g., as an eccentric occupation of the respective control point) should always be treated as a distinct control point. However, a reference or azimuth mark with directions, angles, and/or distances measured from it (as well as to it) for the purpose of verifying and/or supplementing the observations which tie together the control point and its peripheral points may remain a peripheral point. The observations (directions, angles, and/or distances) which link the peripheral points with the respective control points must appear in the appropriate subset of the HZTL OBS data set (see Chapter 2).

Figures 1-1 and 1-2 illustrate an assignment of station serial numbers to control points and to their peripheral points (reference marks, azimuth marks, and/or eccentric points). The numbering system provides unique identifiers for all the survey points. An AZ MK or RM which is being treated as a control point must not also be identified as a peripheral point in the OBS data set. The same station serial number must be consistently used throughout the OBS or DESC data set of a horizontal control job.

As stated in the INTRODUCTION, a horizontal control job consists of two separate data sets - the HZTL OBS data set and the DESC data set. The HZTL OBS data set may contain a greater number of points than the corresponding DESC data set. This might occur when there is no descriptive data for the peripheral points and for unmarked (auxiliary) points. Station descriptions or recovery notes are required only for recoverable survey points. Apart from the peripheral points, there may be a number of nonrecoverable control points (either originally unmarked or confirmed lost) which must be carried along in the OBS data set for network integrity purposes. There may also be recovery notes for stations not used or found destroyed in a survey. Observations for such stations would not be in the OBS data set. In isolated instances, there may be recoverable control points for which no descriptive data are available. In these instances the submitting organization should write a description for each recoverable control point and include it in the DESC data set.

The two data sets of a horizontal control job must be submitted in separate files. These files may be on the same disk or on different disks. In any case, the first record of every data set (see Chapters 2 and Annex P) must contain information positively identifying the data and project: the job code, the data set type, the name of the submitting agency, and the data set creation date.

MEDIA FOR SUBMITTING DATA

Data may be submitted on compact disk (CD), zip disk or floppy disk, CD being generally preferable. The files must be created using a Windows or MS DOS operating system and be in ASCII character format.

The following information must be provided for each disk submitted:

1. Complete name and address of the submitting agency.

2. Number of files and the name of each file on the disk.

3. Method of keying data and machine used (e.g., MTEN on the IBM PC).

4. Name and telephone number of the person to be contacted in case of difficulty with the data.

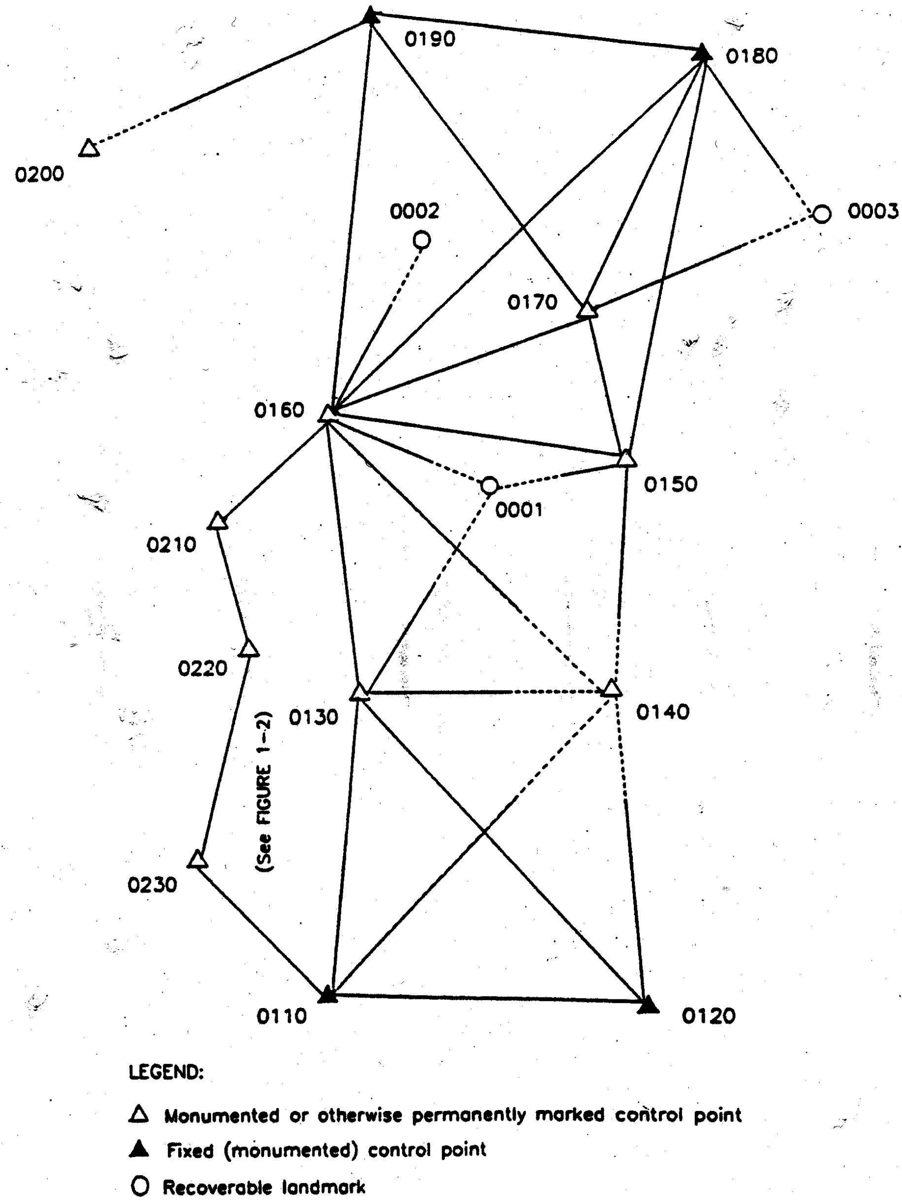


FIGURE 1-1 - STATION SERIAL NUMBERS ASSIGNED TO CONTROL POINTS

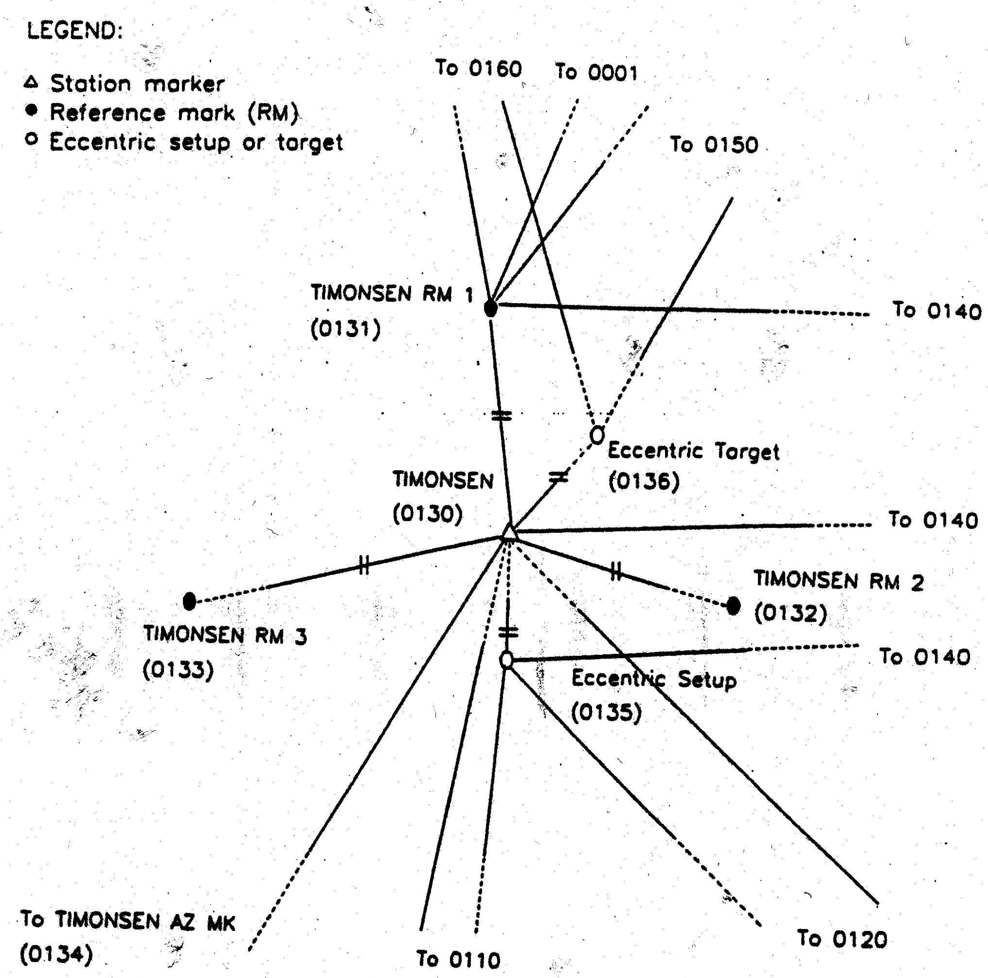


FIGURE 1-2 - STATION SERIAL NUMBERS ASSIGNED TO CONTROL POINTS AND TO PERIPHERAL POINTS.

This information should be furnished in a letter of transmittal. A copy should be packed with the data set.

A letter describing and itemizing the data transmitted 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 retained by the sender. See ANNEX K for current mailing instructions. In every case, the submitting organization should retain a backup copy of all the data shipped until NGS has processed and adjusted the data.

CODING, KEYING, AND DATA VERIFICATION

All data submitted to NGS for insertion into 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 horizontal control jobs are contained in Chapter 2 (HZTL OBS data) and in Annex P (DESC data). The formats were designed to allow the keying and verification of the data to be accomplished on standard computer equipment, hence the 80-character record was adopted as the standard for all applications.

When coding and keying the data entries, carefully insure that alphabetic characters (letters) will be keyed using the alphabetic keys, and that numeric characters (numbers) will be keyed using the numeric keys. In particular, miscoding and miskeying the following characters must be avoided:

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

SPECIAL CHARACTERS

In addition to the alphabetic characters (letters A through Z) and the numeric characters (numbers 0 through 9), only 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
	(() left parenthesis
($) dollar sign	()) right parenthesis

SEQUENTIAL RECORD NUMBERING

The first six characters of every record are nominally reserved for a record sequence number. This number remains useful, but it has become optional; the respective columns may be blank.

The historical purpose of numbering the records was to ensure that the proper sequence of the cards representing individual records in a data set could be verified and, if necessary, restored. The record sequence numbers were intended to be continuous throughout each data set, starting with the first record (the *aa* Data Set Identification Record) and ending with the last record (the *aa* Data Set Termination Record).

The sequence numbers, if used, should begin with 000010 on the first record of the data set 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.

Discounting any after-the-fact inclusions, the sequential numbering system described above will permit a maximum of 99,999 uniquely numbered records in any one data set. Should there be a need for a greater number of records in a data set, start over with 000010, 000020, ... etc.

Chapter 2

HORIZONTAL OBSERVATION (HZTL OBS) DATA

INTRODUCTION

The purpose of this chapter is to provide detailed specifications and instructions for the coding and keying of an observation data set for a horizontal control job. As explained in Chapter 1, a horizontal control job consists of two distinct data sets which must be submitted together. The companion data set to the horizontal observation (HZTL OBS) data set discussed in this chapter is the data set which contains descriptions and/or recovery notes for the control points in the horizontal control job. The descriptive (DESC) data set is discussed in Annex P.

HZTL OBS DATA SET RECORDS

The data which constitute a HZTL OBS data set are organized into nine categories, as follows:

Project Data
Horizontal Direction Data
Global Positioning System Data
Horizontal Angle Data
Vertical Angle/Zenith Distance/Level Data
Distance Data
Azimuth Data
Survey Equipment Data
Control Point Data

Within these categories, the 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 an HZTL 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 reserved for a specific data item. Accordingly, for every desired data item, a field of appropriate length exists into which the data item is entered. The set of rules by which the specific data items are converted into strings of alphanumeric characters is known as the "format" of that record.

The types of records which may appear in a HZTL OBS data set are listed in Table 2-1 on the following page. Each type of record has been given a name.

TABLE 2-1

HORIZONTAL OBSERVATION DATA SET RECORDS

aa - Data Set Identification Record [FIRST RECORD]

10 - Project Title Record
11 - Project Title Continuation Record
12 - Project Information Record
13 - Geodetic Datum and Ellipsoid Record

20 - Horizontal Direction Set Record
21 - Horizontal Direction Comment Record
22 - Horizontal Direction Record

25 - GPS Occupation Header Record
26 - GPS Occupation Comment Record
27 - GPS Occupation Measurement Record
28 - GPS Clock Synchronization Record
29 - GPS Clock Synchronization Comment Record

30 - Horizontal Angle Set Record
31 - Horizontal Angle Comment Record
32 - Horizontal Angle Record

40 - Vertical Angle Set Record
41 - Vertical Angle Comment Record
42 - Vertical Angle Record
45 - Observed Difference of Elevation Record
46 - Observed Difference of Elevation Comment Record
47 - Observed Difference of Elevation Continuation Record

50 - Taped Distance Record
51 - Unreduced Distance Record
52 - Reduced Distance Record
53 - Unreduced Long Line Record
54 - Reduced Long Line Record
55 - Distance Comment Record

60 - Laplace / Astronomic Azimuth Record
61 - Geodetic Azimuth Record

70 - Instrument Record
72 - GPS Antenna Record

80 - Control Point Record
81 - Control Point Record (UTM/SPC)
82 - Reference or Azimuth Mark Record
83, *84* - Bench Mark, Geoid Height Records—discontinued, ignored
85 - Deflection Record
86 - Orthometric Height, Geoid Height, Ellipsoid Height Record

90 - Fixed Control Record—discontinued, ignored
91 - Network Accuracy Record
92 - Local Accuracy Record
93 - Variance Factor Record

aa - Data Set Termination Record [LAST RECORD]

The symbol "aa" denotes the two-character job code assigned by the submitting organization - see Chapter 1.

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 format type for that record (*10*,*11*,...,* - see Table 2-1). In the first and last records of the data set (the Data Set Identification Record and the Data Set Termination Record) the second character field (columns 7-10) contains the two-character alphanumeric job code assigned by the submitting organization (*A1*,*A2*,....., *ZZ* - see Chapter 1). The first character field of every record (columns 1-6) is reserved for the [optional] respective record sequence number - see Chapter 1. The remaining portion of each record (columns 11-80) contains character fields which are unique to each type of record.

STRUCTURE OF THE HZTL OBS DATA SET

The first record of an HZTL OBS data set must be the Data Set Identification Record. It contains the required information to identify the data set and to correlate it with its companion DESC data set - job code, data type (HZTL OBS), name of submitting organization, 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 containing the job code that appears in the same field (columns 7-10) on the Data Set Identification Record.

The HZTL OBS data set is bracketed by these two delimiting records. The data in between may pertain to one or more units of field work. The field observation data for several horizontal control survey projects may be submitted in one HZTL OBS data set under the same job code, provided that the total number of control points does not exceed 9999 (see Chapter 1). When two or more projects are included in one job, each project must be grouped to form a complete unit. Each project must begin with a *10* record and contain any appropriate number of the other types of records in proper sequence.

TABLE 2-2 - HZTL OBS STRUCTURE

Data Set Identification Record	
10 record ... ... *86 record	First Project
10 record ... ... *86 record	Second Project
... ...	... ...
10 record ... ... *86 record	Last Project
Data Set Termination Record	

A horizontal control survey project is defined as a unit of field work containing a number of survey points (control points and peripheral points - see Chapter 1) which are connected by observations - horizontal directions, horizontal angles, vertical angles, distance measurements, and/or Global Positioning System (GPS) phase measurements. When coded as a part of an HZTL OBS data set, a project is a block of records comprising record groups arranged in the following order:

Project Data (*10*-Series) Records:

```
*10*,*11*,*12*,*13* records
```

Horizontal Direction Data (*20*-Series) Records:

```
*20*,*21*,*22*,...,*22* for first set of horizontal directions
*20*,*21*,*22*,...,*22* for second set of horizontal directions
::::
*20*,*21*,*22*,...,*22* for last set of horizontal directions
```

Global Positioning Systems Data (*20*-Series) Records:

```
*25*,*26*,*27*,*27*     for first set of GPS data
*25*,*26*,*27*,*27*     for second set of GPS data
::::
*25*,*26*,*27*,*27*     for last set of GPS data
*28*,*29*               for each clock synchronization
```

(These records may be in any order within the GPS data series records)

Horizontal Angle Data (*30*-Series) Records:

```
*30*,*31*,*32*,...,*32* for first set of horizontal angles
*30*,*31*,*32*,...,*32* for second set of horizontal angles
::::
*30*,*31*,*32*,...,*32* for last set of horizontal angles
```

Vertical Angle/Zenith Distance/Level Data (*40*-Series) Records:

```
*40*,*41*,*42*,...,*42* for first set of vertical angles
*40*,*41*,*42*,...,*42* for second set of vertical angles
::::
*40*,*41*,*42*,...,*42* for last set of vertical angles

*45*,*46*,*47*          for first elevation difference
*45*,*46*,*47*          for second elevation difference
*45*,*46*,*47*          for last elevation difference
```

Distance Data (*50*-Series) Records:

```
*50*,*55* for each taped distance
*51*,*55* for each unreduced line-of-sight distance
*52*,*55* for each reduced line-of-sight distance
*53*,*55* for each unreduced long-line distance
*54*,*55* for each reduced long-line distance
```

Azimuth Data (*60*-Series) Records:

60 for each observed astronomic/Laplace azimuth in the project
61 for each geodetic azimuth used in the project

Survey Equipment Data (*70*-Series) Records:

70 for each item of survey equipment used in the project
72 for each GPS antenna used in the project

Survey Point Data (*80*-Series) Records:

80 or *81* for first control point
82 for each peripheral RM or AZ MK at first control point
85,*86*, as applicable, for first control point
80 or *81* (possibly *82*) for second control point
82 for each peripheral RM or AZ MK at second control point
85,*86*, as applicable, for second control point
::::
80 or *81* (possibly *82*) for last control point
82 for each peripheral RM or AZ MK at last control point
85,*86*, as applicable, for last control point

PROJECT DATA RECORDS

10 - Project Title Record
11 - Project Title Continuation Record
12 - Project Information Record
13 - Geodetic Datum and Ellipsoid Record

The project data records, identified by *10*-series data codes, are listed above; specific formatting is found on pages 2-43 through 2-45.

The *10* record which contains the title of the project is always required; a *11* record is required only if the project title exceeds the 70-character field allowed on the *10* record. Do not divide words between the *10* and *11* records. The *12* record, which contains the date and general location of the survey, the survey method employed and the order classification of the survey, is always required. The *13* record defines the geodetic datum with respect to which geodetic positions, deflections of vertical, geoid heights, and/or ellipsoidal distances given in this project are specified. This record is required only if the geodetic datum is other than the North American Datum of 1983 (NAD 83). Most of the entries on these records are self-explanatory. The following data items will be explained in greater detail:

Project Title: The elements of a good horizontal control survey project title should include (1) the order of accuracy of the survey, (2) the type of the survey, and (3) the geographic locality of the survey. Since the first two elements are coded elsewhere (*12* record), only the geographic locality of the survey needs to be spelled out in the title. The use of geographic locality alone for the title of a horizontal control survey project has traditionally been the practice of NGS and its predecessors.

In general, the title by which the project is known to the submitting agency should be used, supplemented to reflect geographic locality, as required. If the project is best described as covering an area network (triangulation or trilateration), give the geographic locality covered by the survey (e.g., KING COUNTY). If the project is generally linear such as an arc of triangulation or trilateration, or a traverse which is not confined within one locality, then give the geographic localities of its endpoints, in the order of the progress of the survey (e.g., CHARLESTON TO CAPE ROMAIN). Unless it is a part of the geographic locality name, omit the state or country designation if only one state or country is involved. This information will be coded on the *12* record. Otherwise, use abbreviations listed in ANNEX A. Omit commas, periods, etc., and abbreviate in the interest of fitting the entire title on the *10* record, if possible.

Survey Method: A one-digit code is provided on the *12* record to specify the survey method used - triangulation (1), trilateration (2), traverse (3), or GPS (4). For horizontal control survey projects in which more than one survey method is prominent, enter the code for that survey method which best characterizes the project as a whole.

Order and Class of Survey: A two-digit code is provided on the *12* 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 Standards and Specifications for Geodetic Control Networks, prepared and published by the Federal Geodetic Control Committee (FGCC), Rockville, MD (September 1984). In addition to the five horizontal control survey categories defined in this publication, two other survey categories need to be considered - surveys of the Trans-Continental Traverse (TCT) type, and surveys of lower-than-third-order accuracy. The respective two-digit codes are as follows:

AA - AA Order Interferometric Positioning
A0 - A Order Interferometric Positioning
B0 - B Order Interferometric Positioning
00 - Trans-Continental Traverse
10 - First Order
21 - Second Order Class I
22 - Second Order Class II
31 - Third Order Class I
32 - Third Order Class II
40 - Lower Than Third Order

The order-and-class code assigned to a horizontal control survey project should reflect the procedures and specifications by which the main-scheme network was observed. It is understood that many times there are supplemental control points and intersected landmarks to which observations of a lesser order of accuracy are made.

When well-defined parts of a project fall into different order-and-class categories, consideration should be given to dividing the project accordingly and submitting the parts as individual projects. If this is not practical, assign an order-and-class code to the entire project which corresponds to the highest order of accuracy observed (i.e., if networks of both 1st Order and 2nd Order Class I appear in a horizontal control survey project, assign order-and-class code 10 to the project as a whole). In this case, however, special care must be taken to correctly identify the order and type of each horizontal control point on the corresponding *80* or *81* record, according to which order of accuracy main-scheme network the control point belongs - see section entitled SURVEY POINT DATA RECORDS and also see ANNEX E.

DATE AND TIME

The date the HZTL OBS data set was created must appear on the Data Set Identification Record, and the dates on which survey operations commenced and terminated must be entered on one of the project data records (*12* record). In addition, character fields for the date and time of observation are provided on all observation data records. Throughout the HZTL OBS data set, date and time are to be coded as follows:

Date: The 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 last turn of century, month of the year, and day of the month (CCYYMMDD). When the century is omitted, the date is coded as a six-digit integer number denoting the year, month, and day (YYMMDD). The century is required in the DATA SET IDENTIFICATION RECORD (*aa*) and the PROJECT INFORMATION RECORD (*12*). But, in the remaining observation records the six-digit integer number (YYMMDD) is used. For example, 8 February 1970 would be coded as follows:

1. Eight-digit integer number: 19700208
2. Six-digit integer number: 700208

NOTE: The date for GPS data will be coded as a six-digit integer number containing three two-digit groups denoting (left to right) the number of full years since the last turn of the century, month of the year, and the day of the month (YYMMDD).

Time: A five-character field is reserved for the time of day on each observation data record. 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 of a 24-hour clock (HHMM), to be entered in the leftmost four columns of the field. The last column of the five-character time field is reserved for the appropriate one-letter time zone designation(see below). Except for GPS observations, 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).

NOTE: The time for GPS data must be in Universal Coordinated Time (UTC), otherwise known as Greenwich Mean Time (GMT) or ZULU time.

Time Zone: A time zone is a geographic region in which uniform time differing by an integer number of hours from the 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 follow political boundaries and are therefore rather 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 numerical time zone descriptions, it is more convenient to use the U.S. Navy one-letter codes which uniquely identify every time zone around the world. 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 worldwide use of the time zone descriptions and of the U.S. Navy one-letter designations is illustrated in ANNEX H. In the continental United States (US), Alaska (AK), and Hawaii (HI) the time zones are as follows:

TABLE 2-3 - U.S. NAVY TIME ZONE DESIGNATIONS

STANDARD TIME	DAYLIGHT TIME	TIME MERIDIAN	TIME ZONE DESCRIPT'N	U.S. NAVY DESIGNATION
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 last column of the time field blank. In this case, the time coded into the first four columns of the time field will be interpreted as the standard time in a zone determined on the basis of the longitude of the survey point from which the respective observation was taken.

OBSERVATION DATA RECORDS

In connection with classical survey operations, the term "observation" is used to denote one of many angular and linear measurements accomplished to quantify geometric relationships among survey points. In this context, the observations which occur in a horizontal control survey project can be classified as (1) horizontal directions, (2) horizontal angles, (3) vertical angles/zenith distances/leveling, and (4) distance measurements. Astronomic and geodetic azimuths used for orientation control may also be regarded as a type of observation. The HZTL OBS data set records which pertain to these observations are categorized as follows:

20-Series Records - Horizontal Direction/GPS Data
30-Series Records - Horizontal Angle Data
40-Series Records - Vertical Angle/Zenith Distance/Level Data
50-Series Records - Distance Data
60-Series Records - Azimuth Data

Although the GPS data records are not observations as defined here, they are used in conjunction with observational phase measurements to derive the Data Transfer Records (ANNEX N).

The basic element of an observation is a numerical value expressing the measured quantity in appropriate units of measurement. The units of measurement used consistently for all observations in the HZTL OBS data set are (1) sexagesimal degrees, minutes, seconds, and decimals of a second of arc for angular observations, and (2) meters and decimals of a meter for distance measurements. In addition to the respective measured quantity, other elements necessary to describe a horizontal control survey observation are (1) the type of observation, (2) the identity of the survey points from which and to which the observation is taken (standpoint and forepoint - see below), and (3) an estimate of the accuracy of the measured quantity. At times, auxiliary information such as the time of the observation and the height of the instrument and/or target are required in order to obtain proper spacial relationships.

The type of observation is specified by the data code of the record. The survey points associated with an observation are identified by unique, job-specific station serial numbers (see below). A reliable, specific estimate of the overall accuracy of a horizontal control survey observation is rarely at hand. However, a generalized accuracy estimate can be inferred from several data items which are normally available - the order and class of survey, the type of survey equipment used, the number of replications (independent measurements) taken, and the rejection limit enforced. With the exception of the Job-Specific Instrument Number (see below), the observation data items related to the estimate of accuracy of a horizontal control survey observation will be treated in the section entitled ACCURACY OF THE OBSERVATIONS.

Several data items which appear on the observation records are treated below. Detailed explanation of other observation data items is given elsewhere in this chapter.

Standpoint and Forepoint: In connection with a horizontal control survey observation, the point from which the observation is taken (e.g., the point which is occupied with a surveying instrument) will be referred to as the "standpoint" or "instrument station." The point to which the observation is taken (e.g., the point to which the foresight is directed) will be referred to as the "forepoint" or "target station."

Station Serial Number: For the purpose of identifying the standpoint and forepoint on the observation records in a concise manner, each survey point (control point or peripheral point) is assigned a job-specific station serial number (SSN) in the range 0001 to 9999. See Chapter 1 for a detailed explanation of the survey point numbering system. See also ASSIGNMENT OF STATION SERIAL NUMBERS, p. 2-12.

Weather Code: Where applicable, five adjacent integer fields have been reserved on the observation records for one-digit codes. These will be referred to collectively as the "weather code." The first of these codes is a general problem indicator, which should be the digit "0" under normal conditions or the digit "1" if a problem was encountered during an observation, in which case the problem must be explained on one or more comment records to immediately follow the observation record. The other four one-digit codes are indicators of visibility, temperature, cloud cover, and wind, in that order. These indicators may assume the values 0, 1, or 2 (see Table 2-4 below). Any one of these five indicators may be left blank if the condition it represents is either not known or not applicable.

TABLE 2-4 - WEATHER CODE

CODE***	0	1	2
PROBLEM INDICATOR	No Problem Encountered	See Comment	Not Used
VISIBILITY INDICATOR	Good (Over 15 MI)	Fair (7 MI to 15 MI)	Poor (Under 7 MI)
TEMPERATURE INDICATOR	Normal Range (32 F to 80 F)	Hot (Over 80 F)	Cold (Below 32 F)
CLOUD COVER INDICATOR	Clear (Below 20%)	Partly Cloudy (20% to 70%)	Overcast (Over 70%)
WIND INDICATOR	Calm (Under 5 MPH)	Moderate* (5 MPH to 15 MPH)	Strong** (Over 15 MPH)

*No effect on observations. **Possibly affecting observations
***Blank if the condition is not known or not applicable.

Job-Specific Instrument Number: The instrument used to accomplish a horizontal control survey observation must be known; the type of survey equipment (i.e., its resolution and expected accuracy) will be used to compute a standard error for the observation. In order to identify the instrument on the respective observation record in a concise manner, a unique three-digit number in the range 001 to 999 is to be assigned to each item of survey equipment used in the job. In cases where this may be impractical, a three-digit instrument number may be assigned to a class of survey equipment (e.g., all 100-foot uncalibrated steel tapes could be treated as one "instrument"), it being understood that such a class label must correctly reflect the type, resolution, and expected accuracy of all instruments covered by it.

In a manner analogous to the assignment of station serial numbers, the instrument numbers are to be unique throughout a job, i.e., an item of survey equipment which appears in more than one project in the job must be consistently identified by the same number, while different items of survey equipment must be identified by different numbers throughout the HZTL OBS data set. A *70* record must be prepared for each item of survey equipment which has been assigned an instrument number - see SURVEY EQUIPMENT DATA RECORDS.

Job Specific GPS Antenna Number: In a manner analogous to the assignment of job specific instrument numbers, the job specific GPS antenna numbers are to be unique throughout a job; i.e., each GPS antenna which appears in more than one project in the job must be consistently identified by the same number, while different antennas must be identified by different numbers throughout the HZTL OBS data set. A *72* record must be prepared for each antenna which has been assigned an antenna number - see SURVEY EQUIPMENT DATA RECORDS.

Height of Instrument and Height of Target: Horizontal control survey measurements are seldom observed literally mark-to-mark between the survey points involved. Normally, they are measured from a surveying instrument mounted on a tripod, wooden stand, or survey tower erected over the standpoint to a "target" (e.g., a survey light, retro-reflector, or remote instrument) mounted on a similar structure over the forepoint.

The height of instrument (H.I.) is the vertical distance from the top of the occupied survey mark (standpoint) to the optical center of the surveying instrument, positive if the instrument is above the mark, and negative if it is below the mark. This distance is also known as the "height of telescope." Similarly, the height of target (H.T.) is the vertical distance from the top of the survey mark (forepoint) to the point above or below the mark which is used as the target for angular observations, or to the optical center of the retro-reflector (or of the antenna system of the remote instrument) in the case of electronic distance measurements. This distance is also known as the "height of object."

Together with the elevation (and geoid height) of the respective survey points, the height of instrument and the height of target are desired data items in some horizontal control survey observations and required in others. For horizontal directions and horizontal angles, the height of instrument and the height of target are desired for the computation of skew normal and deflection corrections. For vertical angles and distances, the height of instrument and the height of target are required for the reduction of instrument-to-target measurements to mark-to-mark values.

When the surveying instrument cannot be installed directly over the desired survey point and eccentric observations which are to be reduced to center are submitted, the height of instrument entered on the observation record must be the vertical distance between the top of the survey point mark to which the eccentric observations are to be reduced and the horizontal plane passing through the optical center of the horizontally-offset surveying instrument. The same considerations apply to an eccentric target, retro-reflector, or remote instrument.

Height of GPS Antenna: The desired quantity is the vertical distance from the top of the occupied survey mark to the L1 phase center (L1PC) of the antenna used with the GPS receiver. See diagram on page 2-52a.

Visibility Code: Information concerning intervisibility between monumented control points is of great value to the local surveyor, who is not normally prepared to build survey towers over the control points to be occupied or sighted upon. To allow for recording this information, a provision was made for a one-letter visibility code on the observation records which pertains to line-of-sight observations. This code indicates whether or not the forepoint (i.e., a target which might be easily constructed over the forepoint) can be seen from ground level (height of eye) at the standpoint.

Since reference marks, azimuth marks, and the horizontal control point to which they belong are assumed to be intervisible at ground level, the visibility code is further used to indicate whether the forepoint is an RM or an AZ MK associated with the standpoint. The respective one-letter codes are listed below. If a conflict arises in the assignment of a visibility code, the hierarchy implied by this list should be followed. In each case, "forepoint" is meant to describe either a natural target or a simple target installed at height-of-eye level over the forepoint, and "ground" implies height-of-eye level at the respective standpoint.

1. N - Forepoint is not visible from ground.
2. R - Forepoint is an RM associated with standpoint.
3. Z - Forepoint is an AZ MK associated with standpoint.
4. V - Forepoint is visible from ground.

The codes R and Z are to be used only for reference and azimuth marks which are associated with the standpoint, that is, in connection with observations from the respective horizontal control point to its own reference or azimuth marks, or possibly in connection with observations taken among the reference or azimuth marks belonging to the same control point. When the forepoint is an RM or AZ MK which belongs to another control point, the codes N or V, as applicable, should be used. The visibility code field should be left blank if the intervisibility between the respective standpoint and forepoint is not known.

ASSIGNMENT OF STATION SERIAL NUMBERS

The station serial number (SSN) is a unique four-digit number in the range of 0001 to 9999 used to identify every survey point which appears in a HZTL OBS data set. The survey point numbering system is explained in detail in Chapter 1. To recapitulate, a survey point is defined as any point in a survey project which has one or more observations to it or from it. In a horizontal control network, a survey point is either a control point or a peripheral point.

Control Points: A control point is a survey point whose geodetic position is to be determined by the survey project, or whose position has been determined in a previous survey. Examples of a control point are (1) a monumented (or otherwise permanently marked) triangulation, trilateration, traverse, or GPS station; (2) a recoverable landmark (usually an intersection station) such as a flagpole or church spire; or (3) an unmarked (and hence nonrecoverable) survey point which must be carried as a control point for network integrity purposes. A survey point which cannot be positioned because of insufficient observations, whose geodetic position is not available from other sources, and which does not qualify as a peripheral point (see below) must also be treated as a control point, in that such a survey point must be assigned an SSN (see discussion of *82* record, p. 2-80).

Each control point in a horizontal control job must be assigned an SSN. When more than one project appears in a job, care must be taken to ensure (1) that the same SSN is assigned to a control point which several of the projects have in common and (2) that different control points are assigned different SSNs throughout the horizontal control job. The SSNs assigned to control points in the OBS data set of a horizontal control job must match those used to identify the same control points in the corresponding DESC data set. Any unobserved survey point for which a recovery note is submitted in the DESC data set must have a unique SSN.

Peripheral Points: Peripheral points are survey points in the vicinity of a control point which are not intended for positioning, such as reference marks and azimuth marks. These points are still identified by SSNs. Unmonumented eccentric instrument setups and eccentric targets/reflectors are also peripheral points if the respective observations are reduced to center.

An eccentric point, RM, or AZ MK is not always treated as a peripheral point. If the eccentric instrument setup or target/reflector placement is made over a monumented (or otherwise permanently marked) point which can serve as a control point (e.g., when a reference mark is occupied), in many cases it will be desirable to treat the eccentric point as another control point. In any case, when an eccentric point is offset more than 10 meters from the respective control point, the eccentric observations should not be reduced to center (see next section), and the eccentric point should be treated as a control point, whether it is permanently marked or not.

A RM or an AZ MK which has not been occupied (i.e., one which has one or more directions, angles, and/or distances measured to it but not from it) is a peripheral point. But, if it is to be positioned, treat it as another control point. An RM or AZ MK that is occupied as a part of the survey scheme (i.e., as an eccentric occupation of the respective control point) should always be treated as a distinct control point. An RM or AZ MK that has directions, angles, and/or distances measured from it (as well as to it) for the purpose of verifying and/or supplementing the observations which tie together the control point and its peripheral points may remain a peripheral point even though the RM or AZ MK may appear as a standpoint on an observation record in this particular case.

The observations which establish the linkage between a peripheral point and its respective control point must appear among the observation data records. As a minimum, the following observations are required:

1. Eccentric Points: At least one angular observation (horizontal direction or horizontal angle) and one distance measurement, either from the eccentric point to the respective control point, or from the control point to the eccentric point.

2. Reference Marks: At least one angular observation (horizontal direction or horizontal angle) and one distance measurement from the respective control point to the RM in question.

3. Azimuth Marks: At least one angular observation (horizontal direction or horizontal angle) and one distance measurement from the respective control point to the AZ MK in question.

TREATMENT OF ECCENTRIC OBSERVATIONS

When the surveying instrument cannot be installed directly over the desired control point (i.e., when the control point cannot be "occupied"), observations must be made with the instrument offset a short distance from the intended standpoint. Similarly, when the target, retro-reflector, or remote instrument cannot be installed directly over the intended forepoint, observations are made to a target, retro-reflector, or remote instrument which is offset a short distance from the respective control point. When such a condition exists, the offset point from which and/or to which the observations are actually taken is said to be "eccentric" with respect to the control point in question, which is referred to as the "center."

Eccentric observations are normally "reduced to center" as a part of the field computation process. A correction is computed for each eccentric observation from the distance and direction of the offset. After such a correction is applied, the respective observation ceases to be "eccentric." For all practical purposes it is regarded as having been taken from the intended standpoint to the intended forepoint. <u>As a general rule, eccentric observations should be reduced to center by the submitting agency and included in the HZTL OBS data set as normal (i.e., non-eccentric) observations.</u>

When eccentric observations are submitted, care must be taken to select one of the two possible methods of handling eccentric observations which is applicable to the eccentric point in question, and to identify the respective eccentric point accordingly - either as a peripheral point if Method A is applicable, or as a control point if Method B is applicable (see preceding section for definitions of "control point" and "peripheral point").

<u>Method A</u>: <u>The eccentric observations are to be reduced to center</u>. In this case, the eccentric point is identified as a peripheral point. When such a peripheral point is encountered as either a standpoint or forepoint on an observation record, the respective observation will be reduced to center, and the original (eccentric) observation will not be retained. This method is applicable only to eccentric points which are offset no more than 10 meters from the respective control point. For offsets of greater than 10 meters Method B is mandatory.

<u>Method B</u>: <u>The eccentric point is to be treated as a control point</u> whether permanently marked or not. In this case, no reduction to center is involved, as the respective observations are not regarded as eccentric. The eccentric standpoint or forepoint is identified by an SSN just as any other control point (see preceding section). It is given a name (e.g., SMITH ECC, if the name of the respective control point is SMITH), and a *80* or *81* record containing its (approximate) geodetic position must appear among the *80*-series records. This method should be used for eccentric points which are permanently marked, regardless of the offset distance involved. Method B must always be used for eccentric points which are offset by more than 10 meters from the respective control point, whether the eccentric point is permanently marked or not.

ACCURACY OF THE OBSERVATIONS

For every horizontal control survey observation, an estimate of the absolute accuracy of the measured quantity must be available for the purpose of assigning appropriate weight to that observation when it participates in the adjustment of the respective horizontal control network. The absolute accuracy of a measurement is defined as the degree to which the result of that measurement approximates the true value of the measured quantity. Since the true value of a direction, angle, or distance is not known, it then follows that the accuracy of a horizontal control survey observation can only be estimated (1) by comparing the results of different measurements of the same quantity, and (2) by analyzing the misclosures by which the measured quantities fail to satisfy geometric conditions in the respective horizontal control network (e.g., triangle misclosures).

A horizontal control survey observation is rarely made as a single, isolated measurement. Once the required surveying equipment is set over the survey points in question, it is a common practice to measure the same quantity (direction, angle, or distance) several times within a short span of time, each complete measurement being carried out according to an observation scheme which has been carefully designed to eliminate instrumental errors (and possibly other constant and systematic errors as well). The advantage of "replication" is that large blunders can be detected and eliminated, and that the resulting group of measurements can be treated statistical as a random sample.

Each measurement is corrected for any known constant and/or systematic error. Then the resulting corrected sample elements are screened for outliers (larger-than-expected random errors which are suspected to be blunders), usually by the application of a fixed, empirical rejection limit, and the mean of the remaining measurements is used as the best approximation of the true value.

Assuming that the blunders and/or outliers have been eliminated, and that constant and/or systematic errors from all known sources have been eliminated either by the observing procedure or by the application of computed corrections, other errors remain, as evidenced by a random disagreement (however small) which still normally exists among "corrected" sample elements. If another sample of measurements of the same quantity is taken with the same type of instrument but under different environmental conditions, the mean value of the second sample will normally differ from the first sample. If many such samples are taken, the mean values of the re-observed samples will be found to disagree in a random manner as well.

The errors which remain after the blunders and outliers are eliminated and after the sample elements are corrected for constant and systematic errors are seen as random errors of two different kinds. Random errors of the first kind are those errors which manifest themselves as discrepancies among the elements of a sample. Since the presence and general magnitude of these errors are readily apparent when the elements of the sample are compared, random errors of the first kind are known as "sample-internal" or "internal" errors. Random errors of the second kind are those errors which remain constant for all measurements within a sample but vary in a random manner for samples which are reobserved under different conditions. Since they introduce the same bias into every measurement in the sample, the presence and general magnitude of these errors become apparent only when the mean values of several reobserved samples are compared, or when misclosures of geometric conditions in the respective horizontal control network are analyzed. Because of this fact, random errors of the second kind are known as "sample-external" or "external" errors.

The accuracy estimate needed to determine the proper weight for a horizontal control survey observation is the standard error (sigma) reflecting the combined effect of the internal and external errors which affect that observation. Such an estimate of the total uncertainty associated with the respective measured quantity is given by the vector sum (square root of the sum of squares) of the one-sigma estimates reflecting the contributions of the corresponding internal and external errors.

A direct estimate of the contribution of the respective internal errors (i.e., the Internal Consistency Sigma - see below) can be obtained as the standard deviation of the computed sample mean; a value based upon experience may be given when the sample size is one. If no value is specified on the respective observation record (i.e., the field is left blank), a one-sigma estimate can be obtained as a function of the rejection limit and number of replications, or from a default value based on the type of survey equipment used, number of replications taken, and on the order-and-class of the survey.

A direct estimate of the contribution of the respective external errors (i.e., the External Consistency Sigma - see below) is rarely at hand, as horizontal control survey observations are not normally re-accomplished by design under different environmental conditions for the purpose of evaluating the effect of the external errors. A value based on experience may be given; however, if no value is specified on the respective observation record (i.e., the field is left blank), a default value based on the survey equipment used, order-and-class of the survey, and on the type of the survey points involved will be assigned. In connection with triangulation projects, a collective estimate of the external error affecting horizontal directions (or horizontal angles) in that project will be recovered from the set of triangle misclosures when that project is first adjusted by NGS.

The data items which pertain to the accuracy estimate of the respective horizontal control survey observation not treated elsewhere in this chapter are defined below.

<u>Number of Replications</u>: Number of independent measurements of the same quantity, normally carried out within a short span of time (i.e., under the same environmental conditions) by the same personnel using the same equipment (i.e., sample size). In connection with horizontal control survey observations, it is the number of times a complete measurement procedure (observing scheme) is executed with the objective of obtaining a group of measurements the mean value of which is to be used as the observed quantity (e.g., number of positions in a set of horizontal directions).

<u>Rejection Limit</u>: Maximum variation allowed in a group of measurements. The individual measurements which exceed this limit are normally dropped from the sample and hence do not enter into the computation of sample mean. For horizontal directions and horizontal angles, the rejection limit is expressed as the maximum deviation of the individual measurements from the respective sample mean. For vertical angles and for distance measurements, the rejection limit is expressed as the maximum spread between the individual observations included in the sample (i.e., maximum range).

Internal Consistency Sigma: One-sigma estimate reflecting the contribution of the sample-internal random errors to the total uncertainty associated with a measured quantity. In connection with horizontal control survey observations, a direct estimate of the effect of the respective internal errors is usually available as the standard deviation of the computed sample mean. See discussion above concerning the treatment of the accuracy estimate of an observation for which this data item is missing.

External Consistency Sigma: One-sigma estimate reflecting the contribution of the sample-external random errors to the total uncertainty associated with a measured quantity. In connection with horizontal control survey observations, a direct estimate of the effect of the respective external errors is not normally available; however, a value based on experience may be given. See discussion above concerning the treatment of the accuracy estimate of an observation for which this data item is missing.

HORIZONTAL DIRECTION DATA RECORDS

20 - Horizontal Direction Set Record
21 - Horizontal Direction Comment Record (Optional)
22 - Horizontal Direction Record

The horizontal direction data records, identified by *20*-series data codes, are listed above; specific formatting is listed on pp. 2-46 through 2-49.

Since one horizontal direction by itself is meaningless, horizontal directions must be observed in sets of two or more directions. The respective observations are normally recorded in a field record book and later abstracted onto a standard form which is usually referred to as the "abstract of horizontal directions." As recorded on the "abstract," each direction consists of a group of "pointings" observed clockwise from the "initial" (direction to the first object sighted in the observing sequence), which is normally assigned a value of zero. For each forepoint included in the set, the horizontal direction value desired is the mean value of the respective group of pointings (in sexagesimal degrees, minutes, seconds, and decimals of second), corrected for eccentricity of the instrument and/or target, if applicable (see TREATMENT OF ECCENTRIC OBSERVATIONS).

Each set of horizontal directions is to be submitted as a group of records which must begin with one *20* record. In addition to containing information which pertains to the set as a whole, the *20* record also contains the data items associated with the initial direction. Following the *20* record, there may be one or more *21* comment records. These comment records are optional, except when the problem indicator flag on the *20* record (first digit of the weather code) is "1", in which case at least one *21* record containing an explanation of the problem encountered is required.

After the *21* record(s), or immediately after the *20* record if no *21* record(s) are present, one or more *22* records must follow, one for each additional direction observed in the set. Each of these *22* records must have the same standpoint designation and set number (see below) as the *20* record of that horizontal direction set.

When two or more sets of horizontal directions are observed at the same station, each set must be submitted as a separate, complete group of *20*-series records (i.e., a *20* record, one or more *21* records if applicable, followed by one or more *22* records). All sets observed at the same station must be assigned different set numbers and must appear as consecutive sets in the order of increasing set numbers among the *20*-series records.

<u>Set Number</u>: The first set of observations associated with a survey control point is normally coded as 01. Subsequent sets are coded 02, 03, etc. Deviation from this procedure should be explained either in the comment records or in the transmitting letter to prevent someone unfamiliar with the original coding to think that the records were not coded or lost. Sets observed at peripheral eccentric points are considered to belong with the control point and must be numbered as if observed at the control station. Again, the set numbers of successive sets of horizontal directions observed at the same station (including peripheral stations) need not be consecutive, but they must be assembled in increasing order.

<u>Number of Objects Sighted in This Set</u>: The number of forepoints to which directions were observed in the set of horizontal directions, including the initial equals the number of objects sighted in the set. This number minus one is equal to the number of *22* records which must appear behind the *20* record in that set.

<u>Date and Time</u>: The date of observation is required (at least the year) and must appear on every *20* record. The time of observation, when available, is desired to indicate the approximate time of day; any time associated with the set of horizontal directions (e.g., time of first observation, mean time of the set, etc.) is acceptable. Both date and time become required items when one attempts to set parameters for an adjustment based upon date and time constraints.

<u>GLOBAL POSITIONING SYSTEM DATA RECORDS</u>

25 - GPS Occupation Header Record
26 - GPS Occupation Comment Record (Optional)
27 - GPS Occupation Measurement Record
28 - GPS Clock Synchronization Record
29 - GPS Clock Synchronization Comment Record (Optional)

The Global Positioning System records, identified by the *25* - *29* data codes, are listed above; specific formatting is found on pages 2-50 through 2-53.

Whereas observations of classical survey operations are recorded in ASCII format in this text, GPS observations containing code and phase data are recorded by the GPS receiver in a binary format that is unreadable without a translation (e.g., vector reduction) program. The information on the *25* to *29* records and the GPS code and phase measurements are required to derive the information in the GPS Data Transfer Format file (G-File) records: A, B, C, D, E, F, G, H (ANNEX N).

A set of one *25* and two *27* records must exist for each independent occupation of a control point by a GPS receiver. The first *27* record indicates the time when data recording was initiated, plus associated occupation information; the second *27* indicates the time when data recording was completed, plus associated occupation information. Record the time and date referenced to UTC (or Greenwich Mean Time).

A *28* record, used with older receivers which do not recover time from the broadcast GPS signal, is required whenever GPS receivers must be time synchronized to the external time source, e.g., another receiver or a master time source. When using these "codeless" receivers, synchronization must be established between all receivers taking simultaneous measurements. Two synchronizations, normally one before and one after collecting the GPS observations, are required to check receiver clock drift and to verify that no time synchronization errors ("jumps") occurred during the observing period. The *28* record is not required for modern P-code receivers which may be referred to as codeless when in anti-spoofing mode.

The SSN, weather code, and job-specific instrument number fields are required on GPS records. These entries are fully explained in the section <u>OBSERVATION DATA RECORDS</u>, p. 2-8 ff. Other GPS record entries are self-explanatory.

<u>Job-Specific Data Media Data Identifier:</u> Since the GPS observables (code and phase data) can not be practically accommodated in the formats of this text, they must be submitted in manufacturer specific or RINEX (Receiver Independent Exchange) data file formats. Depending upon the receiver type, one or more files may be generated. However, it is still necessary to associate a specific set of data file(s) to a specific occupation. This is done by the user who assigns a 10-character identifier for each station occupation. These identifiers are unique to a specific project and reflect information on the physical or digital labels of the phase data files. The main function of the data media identifier is to provide to NGS a one-to-one correspondence between a control point occupation and a GPS data file. The standard format for the data media identifier can be found in ANNEX N.

<u>HORIZONTAL ANGLE DATA RECORDS</u>

30 - Horizontal Angle Set Record
31 - Horizontal Angle Comment Record (Optional)
32 - Horizontal Angle Record

The horizontal angle data records, identified by *30*-series data codes, are listed above; specific formatting is found on pages 2-54 through 2-58.

Horizontal angles (clockwise), as opposed to horizontal directions, are normally observed in connection with surveys of low accuracy (e.g., third order or lower) using repeating theodolites and engineer's transits. The characteristic feature of these instruments is the double concentric motion about the vertical axis by means of which the horizontal circle can be set precisely to zero when one of the forepoints is sighted upon, and the desired horizontal angle to another forepoint can be "repeated"; i.e., measured several times in succession, each time allowing the horizontal circle reading to be incremented by the magnitude of the measured angle. The desired angular measure, expressed to a greater precision than the resolution of the respective instrument, is obtained when the total angle accumulated on the horizontal circle is divided by the number of "repetitions."

The number of repetitions must not be confused with the number of replications, as one angle measurement by this method, involving any number of repetitions, constitutes but <u>one</u> determination of that angle (i.e., <u>one</u> replication).

Normally, several such determinations are made; the desired horizontal angle value is the mean value of the respective group of measurements (in sexagesimal degrees, minutes, seconds, and decimals of second), corrected for eccentricity of instrument and/or target, if applicable (see TREATMENT OF ECCENTRIC OBSERVATIONS). Two forepoints are involved with every horizontal angle observation; the value given must be the clockwise angle from the first (left) forepoint to the second (right) forepoint.

Since a horizontal angle is a complete observation in itself, every horizontal angle may be submitted as a "set of size one," i.e., as a *30* record followed by one or more *31* comment records. These comment records are optional, except when the problem indicator on the *30* record (first digit of the weather code) is 1, in which case at least one *31* record containing an explanation of the problem encountered is required. When more than one angle is measured as a part of the same observing scheme (e.g., angle observation by Schreiber's method), the additional angles in the same set should be submitted as *32* records to follow after the *31* record or records, or immediately after the *30* record if no *31* records are present. In addition to the same standpoint designation, each of these *32* records must bear the same set number (see below) as the *30* record of that horizontal angle set.

When two or more sets of horizontal angles are observed at the same station, each set must be submitted as a separate, complete group of *30*-series records (i.e., a *30* record, one or more *31* records if applicable, followed by one or more *32* records). All sets observed at the same station must be assigned different set numbers and must appear as consecutive sets in the order of increasing set numbers among the *30*-series records. If horizontal angles are to be reduced to center, the sets observed at peripheral eccentric points of the same control point must appear as members of the same sequence together with any set or sets observed directly over the corresponding control point.

Set Number: Normally coded as 01, unless two or more sets of horizontal angles observed at the same standpoint (either between the same or between different forepoints), in which case these sets must appear adjacent among the horizontal angle data records. The first set in the sequence must be assigned a two-digit set number, e.g., 01, and each additional consecutive set bearing the same standpoint designation must be assigned a higher number, e.g., 02, 03, etc. For this purpose, sets observed at peripheral eccentric points are considered to belong with the respective control point and must be grouped accordingly. The set numbers of successive sets of horizontal angles observed at the same station need not be consecutive; however, they must be increasing.

Number of Angles Observed in This Set: Total number of horizontal angles observed as a part of the same observing scheme. This number minus one equals the number of *32* records which must appear behind the respective *30* record in that set.

Date and Time: Date of observation is required (at least the year) and must appear on every *30* record. Time of observation, where available, is desired to indicate the approximate time of day; any time associated with the horizontal angle observation (e.g., starting time, mean time, ending time, etc.) is acceptable. Both date and time become required items when one attempts to set parameters for an adjustment based upon date and time constraints.

VERTICAL ANGLE/ZENITH DISTANCE DATA RECORDS

40 - Vertical Angle Set Record
41 - Vertical Angle Comment Record (Optional)
42 - Vertical Angle Record

The vertical angle/zenith distance data records, identified by *40*-series data codes, are listed above; specific formatting is found on pages 2-59 through 2-61.

Vertical angles (or zenith distances) are observed in connection with classical horizontal control survey projects for the purpose of obtaining elevation differences between horizontal control points by trigonometric leveling. The elevation of one or more of the survey points involved must be reliably known from some other source.

In addition to vertical angles and distances between survey points, the determination of the elevation differences by trigonometric leveling requires a knowledge of the geoid height at every survey point involved and of the deflection of vertical in the direction of each vertical angle observed at every standpoint. Since geoid heights and deflections of the vertical are seldom known, it is a common practice to assume a zero value for these quantities, and therefore only approximate results can normally be obtained. For this reason, vertical control should not be extended by this method without frequent ties to existing bench marks in the project area. Aside from the difficulties mentioned in the preceding paragraph, trigonometric leveling suffers from a large uncertainty due to atmospheric refraction. This uncertainty is brought about by the unpredictable nature of the irregular, preponderantly vertical bending of an optical ray due to the variation of the refraction gradient along its path. This effect of atmospheric refraction is the dominant source of the external random error associated with vertical angle observations. To control the influence of this external error, the magnitude of which grows with the length of the observed line, reciprocal vertical angles are often observed simultaneously or nearly simultaneously from both ends of the respective line.

In a manner similar to other types of horizontal control survey observations, a vertical angle is usually measured several times in rapid succession following a standard observing scheme. The desired vertical angle value is the mean value of the respective group of measurements (in sexagesimal degrees, minutes, seconds, and decimals of second) accompanied by the appropriate angle code (see below) which identifies the value given as an elevation angle (E), depression angle (D), or a zenith distance (Z). Since the magnitude of the dominant external error affecting the vertical angle measurement is proportional to the length of the observed line (see above, the respective External Consistency Sigma is expressed as seconds of arc per kilometer.)

A vertical angle is a complete observation in itself; hence every vertical angle may be submitted as a "set of size one," i.e., as a *40* record followed by one or more *41* comment records. These comment records are optional, except when the problem indicator on the *40* record (first digit of the weather code) is 1, in which case at least one *41* record containing an explanation of the problem encountered is required. When two or more vertical angles to different forepoints are measured at a station as a part of the same observing scheme, the additional vertical angles in the same set should be submitted as *42* records to follow the *41* record or records, or immediately after the *40* record if no *41* records are present. In addition to the same standpoint designation, each of these *42* records must bear the same set number (see below) as the *40* record of that vertical angle set.

When two or more sets of vertical angles are observed at the same station, each set must be submitted as a separate, complete group of *40*-series records (i.e., a *40* record, one or more *41* records if applicable, followed by one or more *42* records). All sets observed at the same station must be assigned different set numbers and must appear as consecutive sets in the order of increasing set numbers among the *40*-series records. For this purpose, sets observed at peripheral eccentric points of the same control point must appear as members of the same sequence together with any set or sets observed directly over the corresponding control point.

<u>Set Number</u>: Normally coded as 01, unless there are two or more sets of vertical angles observed at the same standpoint (either to the same or to different forepoints), in which case these sets must appear adjacent among the vertical angle data records. The first set in the sequence must be assigned a two-digit set number, e.g., 01, and each additional consecutive set bearing the same standpoint designation must be assigned a higher number, e.g., 02, 03, etc. For this purpose, sets observed at peripheral eccentric points are considered to belong with the respective control point and must be grouped accordingly. The set numbers of successive sets of vertical angles observed at the same station need not be consecutive; however, they must be increasing.

<u>Number of VAs or ZDs Observed in This Set</u>: Number of forepoints to which vertical angles (or zenith distances) were observed as a part of the same observing scheme. This number minus one equals the number of *42* records which must appear behind the respective *40* record in that set of vertical angles.

<u>Date and Time</u>: Date of observation is required (at least the year) and must appear on every *40* record. The full date and the time of the vertical angle observation to each forepoint involved should be supplied whenever possible, so that any search based on date and time can be made for simultaneous or nearly simultaneous reciprocal vertical angle observations. For this purpose, a time field appears on the *42* record as well as on the *40* record.

<u>Angle Code</u>: Vertical angles are measured with respect to the direction of the gravity vector at the respective standpoint by theodolites or transits equipped with appropriate vertical circles. Depending on the instrument, the origin (zero graduation mark) of the vertical circle points either in a direction perpendicular to that of the gravity vector, in which case the origin of the vertical circle lies in the local astronomic horizon, or else it points in the direction opposite to that of the gravity vector, in which case the origin of the vertical circle indicates the local astronomic zenith.

When the zero of the vertical circle defines the astronomic horizon, the vertical angle measured is an "elevation angle" or a "depression angle" depending on whether the object sighted is above or below the astronomic horizon. When the zero of the vertical circle points in the direction of the astronomic zenith, the vertical angle measured is a "zenith distance." The zenith distance of an object above the astronomic horizon will be less than 90 degrees, while the zenith distance of an object below the astronomic horizon will be greater than 90 degrees.

The angle code is a one-letter indicator of the type of the vertical angle given. The three possible codes are as follows:

E - elevation angle
D - depression angle
Z - zenith distance

DIFFERENCE OF ELEVATION (LEVEL) DATA RECORDS

45 - Observed Difference of Elevation Records
46 - Observed Difference of Elevation Comment Record
47 - Observed Difference of Elevation Continuation Record

The difference-of-elevation data records, identified by *40*-series data codes, are listed above; specific formatting is found on pages 2-62 through 2-63.

Differences of elevation are observed in connection with classical horizontal control survey projects in order to maintain an observed difference of elevation relationship between two horizontal control points for the purpose of data reduction. Both horizontal control points generally do not have established vertical elevations. However, either one of these two control points could already have an established and published elevation.

In a manner similar to other types of horizontal control survey observations, a difference of elevation is usually measured at least twice (once in the forward direction and once in the reverse or backward direction) as standard observing practice. The desired difference of elevation is then the mean value of the two respective differences of elevation. However, each level running (i.e., forward and backward) can be considered as an independent observation and can be coded as a separate observed difference of elevation data set.

Since a difference of elevation is a complete observation in itself, each observation is submitted as a *45* record, followed by one or more *46* comment records, followed by a *47* record. The comment records are optional, except when the problem indicator on the *45* record (first digit of the weather code) is 1, in which case at least one *46* record containing an explanation of the problem encountered is required. The *47* record must bear the same standpoint designation as the *45* record preceding it.

When two or more sets of differences of elevation are observed at the same station, each set must be submitted as a separate, complete group of *40*-series records (i.e., a *45* record, one or more *46* records if applicable, followed by a *47* record).

Number of Replications: The number of replications for a single difference of elevation observation is one. If the difference of elevation is the mean value of two level runnings of the same section (i.e., forward and backwards) then the number of replications is coded as 2.

Date and Time: The date of observation is required (at least the year) and must appear on every *45* record. The full date and time for the leveling observation should be supplied whenever possible. The observation time coded should be the mid-time for the running of the section.

DISTANCE DATA RECORDS

50 - Taped Distance Record
51 - Unreduced Distance Record
52 - Reduced Distance Record
53 - Unreduced Long Line Record
54 - Reduced Long Line Record
55 - Distance Comment Record (Optional)

The distance data records, identified by *50*-series data codes, are listed above; specific formatting is found on pages 2-64 through 2-72.

Submit a *50*, *51*, *52*, *53*, or *54* record, followed by one or more *55* comment records, for every distance determination in the horizontal control survey project. The comment records are optional, except when the problem indicator (first digit of the weather code) is 1, in which case at least one *55* record containing an explanation of the problem encountered must follow the respective *50*, *51*, or *52* distance record. The weather code has been omitted on the *53* and *54* long-line records. In every case, the desired distance value is the mean value of the respective group of replicated measurements to which all corrections applicable to that type of distance measurement have been applied (in meters and decimals of meter), further corrected for eccentric setup at either end of the measured line, if applicable (see TREATMENT OF ECCENTRIC OBSERVATIONS). It must be accompanied by the appropriate distance code (see below) which identifies the distance value given as to its type.

The *50* record is intended for distances measured with either calibrated or uncalibrated (i.e., standardized or not standardized) steel or invar tapes. Included are distances consisting of any number of segments taped horizontally, taped distances consisting of any number of segments which have all been reduced individually to a common horizontal reference surface (other than the sea level or the ellipsoid), and one-segment unreduced taped distances (less than or equal to one tape length) measured along a slope. The limitation to only one segment in this last case is forced by the additional data items (the elevation difference between the respective marks and the heights of tape supports over the marks) required for each such taped distance segment. Excluded are taped distances which have been reduced to sea level (geoid), to the ellipsoid, or to mark-to-mark, for which the *52* record should be used. In every case, the respective standardization, catenary, and temperature corrections, as applicable to the method of measurement and/or to the equipment used, are assumed to have been applied.

The *51* record is intended for unreduced slant-range distances under 100 kilometers measured by electronic distance-measuring equipment (DME). Included are line-of-sight instrument-to-reflector distances measured by electro-optical DME and master-to-remote distances measured by microwave DME with a resolution (i.e., smallest directly readable measurement unit) of 1 centimeter or better.

Excluded are distances measured to a precision coarser than 1 centimeter (because the respective Rejection Limit, Internal Consistency Sigma, and External Consistency Sigma should be expressed in different units), which may be submitted as *53* records. In every case, the respective instrument and/or reflector calibration corrections and refraction correction, as applicable to the method of measurement and/or to the equipment used, are assumed to have been applied.

The *52* record is intended for taped distances, and for distances under 100 kilometers measured by electronic DME with a precision of 1 centimeter or better, which have been reduced (1) to sea level (i.e., to the geoid), (2) to the ellipsoid (either NAD 83 or as specified on the *13* record), or (3) to mark-to-mark. For the same reason given in the preceding paragraph, reduced distances measured to a coarser precision than 1 centimeter should be submitted as *54* records. In every case, the distance given is assumed to be the appropriately reduced value corresponding to the mean of the respective sample of distance measurements to which all applicable corrections have been applied. Among the required data items are elevations (and of the geoid heights, if applicable) which were used in the reduction process (possibly different than those provided on the corresponding *80*-series records).

The preponderant external random errors affecting precisely taped distances or line-of-sight distances measured by fine-resolution electronic DME arise out of the inadequacy of the mathematical models used to correct the respective distance measurements for distance-dependent systematic errors, such as the temperature and catenary corrections in case of taped distances, or the refraction correction in case of distances measured by precise electro-optical or electro-magnetic DME. The magnitude of the respective external random errors is therefore also proportional to the length of the measured line. For this reason, the External Consistency Sigma on the *50*, *51*, and *52* records is expressed as a parts-per-million (ppm) value.

The *53* and *54* records are counterparts of the *51* and *52* records intended, respectively, for unreduced and reduced long-line distances (100 kilometers and longer) measured with either fine or coarse resolution by an indirect method. Examples of such long-line distances are the antenna-to-antenna spatial chords and the corresponding reduced sea-level (geoidal), ellipsoidal, or mark-to-mark distances derived from line-crossing measurements made with a long-range, airborne electro-magnetic DME (e.g. HIRAN), or obtained by extraterrestrial techniques (e.g., VLBI). These records may also be used, respectively, for unreduced and reduced slant-range distances under 100 kilometers measured directly by a coarse-resolution DME. Since the preponderant external random errors associated with long-line and/or coarse-resolution distance measurements do not normally exhibit any relationship with the length of the respective line, the External Consistency Sigma on the *53* and *54* records is expressed in meters.

Date and Time: Date of observation is required (at least the year) and must appear on every distance observation record. Time of observation, where available, is desired to indicate the approximate time of day; any time associated with the distance observation (e.g., starting time, mean time, ending time, etc.) is acceptable.

Distance Code: A one-letter indicator of the type of distance involved. This indicator must appear immediately following the distance field on the distance observation records. The possible distance codes are as follows:

1. Unreduced Distances:

   T - distance taped horizontally

   H - taped distance reduced to horizontal
   S - slope distance or slant-range distance
   C - spatial chord distance

2. Reduced Distances:

   G - sea-level (geoidal) distances
   E - ellipsoidal distances
   X - mark-to-mark distances

AZIMUTH DATA RECORDS

60 - Laplace/Astronomic Azimuth Record
61 - Geodetic Azimuth Record

The azimuth data records, identified by *60*-series data codes, are listed above; specific formatting is found on pages 2-73 through 2-75.

A Laplace azimuth is an astronomic azimuth determination (e.g., by observation of the star Polaris) converted to a corresponding geodetic azimuth by the application of the Laplace correction. A data element necessary for the computation of the Laplace correction is the east-west (prime-vertical) component of the deflection of vertical at the respective standpoint. If the deflection component is not known from other sources, an astronomic longitude must also be observed. A horizontal control point at which the prime-vertical component of the deflection of vertical is known, and at which a determination of astronomic azimuth has been made, is called a "Laplace station."

Laplace azimuths are the primary means for orienting a survey project if the orientation cannot be obtained with respect to established horizontal control points (e.g., because of intervisibility problems). When a survey project is extended away from existing horizontal control, Laplace stations must be established at regular intervals to guard against the buildup of systematic errors which may cause a gradual swing in the orientation of the network.

Submit a *60* record for each astronomic or Laplace azimuth used in the project. If there are two or more sets of astronomic azimuth observations (e.g., sets observed on different nights), submit a separate *60* record for each set. The desired Laplace azimuth is the mean value of the respective set of astronomic azimuth observations to which all applicable corrections, including the Laplace correction, have been applied (in sexagesimal degrees, minutes, seconds, and decimals of second), further corrected for eccentricity of instrument and/or target, if applicable (see TREATMENT OF ECCENTRIC OBSERVATIONS).

A required data item on the *60* record is the Prime-Vertical Component of

Deflection (Eta), i.e., the difference between the astronomic and geodetic longitudes of the standpoint, as used in the computation of the expressed Laplace correction. In addition to its absolute numerical value in seconds, the direction of the prime-vertical component of the deflection of vertical, i.e., the Direction of Eta must be specified as "E" or "W" according to whether the astronomic longitude falls east or west of the corresponding geodetic longitude of the standpoint.

The results of astronomic observations in the form of an astronomic azimuth or a computed Laplace azimuth and the meridional and prime-vertical components of the deflection of vertical are called for on the *60* and *85* records of the HZTL OBS data set. In addition, the respective astronomic latitude, longitude, and/or azimuth observations should be submitted separately in full detail for rigorous processing and incorporation into the astronomic data file of the National Geodetic Survey Data Base.

Geodetic azimuths are used when orientation control for a survey project is obtained with respect to the existing horizontal control network by including an azimuth reference object (e.g., the azimuth mark) among the forepoints to which horizontal directions or horizontal angles are observed at one or more existing horizontal control points.

Submit a *61* record containing the respective geodetic azimuth value (in sexagesimal degrees, minutes, seconds, and decimals of second) for every azimuth reference object to which a horizontal direction or horizontal angle has been observed for the purpose of providing orientation control for the survey project. But, do not submit a *61* record if the azimuth reference object in question is another control point in the HZTL OBS data set, i.e., if a *80* or *81* record defining its geodetic position appears among the *80*-series records (see SURVEY POINT DATA RECORDS).

Date and Time: The date of the astronomic azimuth observation is required (at least the year) and must appear on the respective *60* Astronomic/Laplace Azimuth Record. The time of observation is desired to indicate the approximate time; any time associated with the astronomic azimuth observation (e.g., starting time, mean time, ending time, etc.) is acceptable. Date and time have been omitted on the *61* Geodetic Azimuth Record, since one does not observe a geodetic azimuth. It is a computed quantity.

Origin of Azimuth: A one-letter code indicating the branch of the meridian (north or south) with respect to which the azimuth given on a *60* or *61* record is specified. The azimuth of a line joining a standpoint and a forepoint is defined as the clockwise horizontal angle (0 to 360 degrees) measured from either the north or the south branch of the meridian at the standpoint to the forepoint in question. Since the azimuth may be defined as either "from the north" or "from the south," the origin of the azimuth must be specified as "N" or "S", whichever applies. In the NAD 27 system of coordinates, astronomic and geodetic azimuths are defined as originating from the south. In the NAD 83 system of coordinates, astronomic and geodetic azimuths are defined as originating from the north.

SURVEY EQUIPMENT DATA RECORDS

70 - Instrument Record
71 - GPS Antenna Record [superseded by *72* record]
72 - GPS Antenna Record

The survey equipment data records, identified by *70*-series data codes, are listed above; specific formatting is found on pages 2-76 through 2-76b.

The purpose of the *70* record is to provide descriptive information pertaining to an item of survey equipment which has been identified by a Job-Specific Instrument Number (see p. 2-8 ff, OBSERVATION DATA RECORDS,). Submit a *70* record for each item of survey equipment used in the project. Individual *70* records should appear in order of increasing Job-Specific Instrument Numbers (JSIN). More than one *70* record is required for any instrument used for more than one type of measurement. In other words, a theodolite used to measure both horizontal and vertical angles would require two *70* records: one to record the resolution of the horizontal measurements and the other to record the resolution of the vertical measurements. The resolution and units symbol (see below) of these two records would be different, but the JSIN and the NGS Survey Equipment Code would be identical.

If a "total station" type instrument is used in a survey, three *70* records may be required (horizontal directions, vertical angles and distance observations) for one JSIN. If this equipment is self-contained, the JSIN and the NGS Survey Equipment Code will be identical in each of the three records as stated above. Refer to the Total Station category (800-860) in ANNEX F. But, if modular type equipment (optional EDM instruments can be mounted on the same "total station" base unit) is used, the NGS Survey Equipment Code in the *70* record, which reflects the resolution of the distance measurements, must be that of the specific EDM instrument used for the observations. (Refer to Distance-Measuring Equipment categories (500-799) in ANNEX F). The equipment code for the other two *70* records would be listed in the Total Station category (861-899) in ANNEX F.

Most of the entries on the *70* record are self-explanatory. The following data items will be explained in greater detail:

NGS Survey Equipment Code: A three-digit numerical identification code is assigned to the different categories of survey equipment, and within each category to specific instruments or other items of survey equipment commonly used in the United States - see ANNEX F.

Resolution of the Instrument and Units: The size of the smallest directly readable linear or angular measurement unit characteristic of the respective item of survey equipment, followed by a two-letter symbol for the units in which it is expressed:

MT - meters	HS - horizontal seconds of arc
MM - millimeters	HM - horizontal minutes of arc
FT - feet	VS - vertical seconds of arc
MF - millifeet	VM - vertical minutes of arc

The character fields reserved for Resolution of the Instrument and for Units on the *70* record may be left blank if the resolution of the surveying instrument in question cannot be expressed in these units (e.g., if the measurement is obtained in terms of arbitrary "dial" units which do not bear a fixed relationship to the measured quantity). Leave these fields blank if GPS equipment is used.

The purpose of the *72* [formerly *71*] record is to provide descriptive information pertaining to the GPS antenna which has been identified by a Job-Specific Antenna Number (see p. 2-8 ff, OBSERVATION DATA RECORDS). Submit a *72* record for each antenna used in the project. Individual *72* records should appear in order of increasing Job-Specific Antenna Numbers (JSAN).

Most of the entries on the *72* record are self-explanatory. The following data items will be explained in greater detail:

NGS Antenna Code: An alpha-numeric identification code of up to 16 characters is assigned to each different type of GPS antenna commonly used with GPS receivers in the United States. See ANNEX M.

Antenna Phase Pattern File: This file contains elevation-dependent phase patterns and offsets for several different types of antennas. As this file is updated, the patterns and/or offsets may be changed, so it is important to record which antenna file was used for the GPS processing. To date (March, 2003), NGS has had three files available for use--ant_info.001, ant_info.002 and ant_info.003. These Antenna Phase Pattern files will be modified as new antennas are added or as improved patterns are developed. For each antenna in the respective ant_info file, there are the test-developed patterns and North, East and Up offsets of the L1 and L2 phase centers.

Source Organization: Use the six-character symbol of the organization that maintains the antenna phase pattern files that were used to process the data. This field is required if the antenna phase patterns used are different from those provided by NGS.

SURVEY POINT DATA RECORDS

80 - Control Point Record
81 - Control Point Record (UTM/SPC)
82 - Reference or Azimuth Mark Record
85 - Deflection Record (Optional)
86 - Orthometric Height, Geoid Height, Ellipsoid Height Record

The survey point data records, identified by *80*-series data codes, are listed above; specific formatting is found on pages 2-77 through 2-85.

Submit a group of *80*-series records for every control point which appears in the horizontal control survey project. See ASSIGNMENT OF STATION SERIAL NUMBERS for definition of "control point" and "peripheral point" and for an explanation of the survey point numbering system. Start with the control point identified by the numerically lowest SSN and continue with control points in the order of their increasing (not necessarily consecutive) SSNs.

The group of *80*-series records pertaining to a control point will usually consist of either a *80* record or a *81* record followed by as many *82* records as there are peripheral reference marks and/or azimuth marks associated with the horizontal control point in question. Use the *80* record if the geodetic position of the control point (see below) is given in geographic coordinates (latitude and longitude); use the *81* record if the position is given either in the Universal Transverse Mercator (UTM) coordinates or in State Plane Coordinates (SPC). Following the *80* or the *81* record, submit one *82* record for each peripheral RM or AZ MK of that control point. Do not submit a *82* record for an RM or AZ MK which is being treated as a control point for which a *80* or *81* record appears elsewhere among the survey point data records. After the *82* records, or after the *80* or *81* record if no *82* records are present, a *85* record may follow, followed by a *86* record. A *85* record should be submitted if either one or both the meridional and prime-vertical components of the deflection of vertical are known. Submit a *86* record for each *80* or *81* record, except for unmonumented recoverable landmarks positioned by intersection. See discussion of the *86* record on p. 2-83 ff.

Two special cases are recognized, in which a *82* record must be submitted for a control point instead of the usual *80* or *81* record. The first case has to do with survey points which would normally be regarded as horizontal control points (i.e., they do not qualify as peripheral points), which cannot be positioned because of insufficient observations, and whose geodetic position cannot be obtained from other sources. Such a survey point must be identified just as a normal control point, however, since the respective geodetic position is not available; submit a *82* record in lieu of a *80* or *81* record, then proceed as for any other normal control point, i.e., submit additional *82* records, a *85* record, and a *86* record, as applicable.

The second case has to do with survey points which are used as vertical control points only, i.e., bench marks or other points to which and/or from which one or more vertical angles and distances have been observed, but no horizontal directions or angles. Survey points of this kind must also be identified by SSNs. If such a survey point is positionable (e.g. by trilateration), then it should be treated as a normal control point. Otherwise, submit a *82* record for this point in lieu of a *80* or *81* record. A *85* record may follow, if applicable, but a *86* record is required. Additional *82* records are not allowed in this set. Should such a point have any peripheral reference or azimuth marks, then it should be treated as in the first special case, described in the preceding paragraph.

For the purpose of easy identification, any *82* records, used in lieu of *80* or *81* records as described in the special cases above, should be grouped together and sequenced to follow all the control points with geodetic positions.

Most of the entries on the *80*-series records are self-explanatory. The following data items will be explained in greater detail:

Station Name: In the United States, it has traditionally been the preferred practice at the National Geodetic Survey (NGS) and its predecessors to assign intelligible names as primary identifiers of horizontal control points. Such "station names" have the important advantage of being mnemonic - a quality which pure numbers or arbitrary alphanumeric symbols do not possess. In addition, a properly chosen station name may in itself be descriptive and/or indicative of the general location of the horizontal control point, which is a desirable property. For data processing purposes, however, the use of station names as primary identifiers does pose some difficulties. Their length must be limited to a specific number of characters, and consistency of use is required--exactly the same abbreviation and/or spelling of the respective station name must be used whenever reference is made to a horizontal control point in computer-readable media.

The name of a monumented horizontal control point is usually concise, being limited in length by the space which is available on a standard disk marker for the die-stamping of the respective station name. The usual practice is to stamp the name above the survey point symbol (e.g., triangle) which appears in the center of a standard disk marker, and the year (e.g., 1935) in which the mark was set is usually stamped below the survey point symbol.

In addition to this "year mark set" which normally appears stamped on every monumented survey point, another date is associated with every horizontal control point, i.e., with every survey point which is positioned, whether it is a monumented control point or an unmonumented recoverable landmark (see below). Referred to as the "year established," it is the year in which observations were first performed for the purpose of determining the position of that horizontal control point; this is normally also the year in which the original description of that control point was prepared. The "year established" and "year-mark-set" of a monumented horizontal control point are often identical.

Another type of horizontal control point is an unmonumented recoverable landmark (usually an intersection station) such as a flagpole or church spire. The name of a horizontal control point of this type must be sufficiently descriptive in order to identify the respective landmark (and frequently a specific feature of the landmark) adequately, and for this reason it is usually lengthy.

For data processing purposes in HZTL OBS data sets, the length of a station name (including all imbedded blanks) is limited to 30 characters. The same limit applies to the name or designation of a reference mark (RM) or azimuth mark (AZ MK). Accordingly, the name of every horizontal control point to be entered on the *80* or *81* record (as well as the name or designation of an RM or AZ MK to be entered on the *82* record) must be abbreviated and/or edited if it exceeds 30 characters. Guidelines for survey point names and designations, including recommended abbreviations, are given in ANNEX D. Note that the name or designation of a bench mark (BM) is limited to 25 characters (see Volume II, Chapter 6, pages 6-17 and 6-35, <u>Designation</u> and <u>*30* record</u>).

For some of the lengthier names given to horizontal control points (e.g., those of unmonumented recoverable landmarks) contraction to 30 characters will involve rather drastic abbreviation and editing, in which process much of the desired intelligibility and descriptiveness may be lost. To minimize this effect in connection with geodetic materials which are intended for use by the general public, up to 50 characters are allowed for the name of a horizontal control point in the DESC data set (see Annex P, section 3.3.1, Description Header Record, Field Format of Designation). This 50-character station name will be used in the publication of geodetic data sheets, station descriptions, and associated indexes. Two versions of a station name which exceeds 30 characters in length can thus exist - a 30-character version shortened for data processing purposes, and a 50-character version used for publication purposes. The two versions should differ only as to the manner in which the station name is abbreviated and/or edited.

The name of a horizontal control point entered on the *80* or *81* record should be taken as it appears under "Station Name" in the heading of the respective station description and subsequent recovery notes. For monumented horizontal control points, this station name is normally identical to or closely resembles the name stamped above the survey point symbol on the respective disk marker. Note that neither the "year established" nor the "year mark set" normally appears as a part of the station name. While parts of a lengthy station name may be abbreviated or edited out in order to conform to the 30-character limit, <u>nothing should be added</u>, except as necessary to render the station name unique within the job (see below).

Parentheses are not permitted to appear in a station name. Other special characters such as periods, commas, etc. (see Chapter 1) - as well as any unnecessary spaces (blanks) - should also be edited out whenever possible.

In the same manner as the SSN of a horizontal control point is unique within a job, it is highly desirable to have a station name that is unique within a job. If two or more control points in a job are found to have identical names, they should be rendered unique by appending to the respective station names, in order of preference:

1. The name of the county (parish, census division) in which the station is located, followed by the symbol CO, PA, or CD as appropriate -
   <u>Examples</u>: JONES <u>CLALLAM CO</u> and JONES <u>KING CO</u>; SMITH <u>ORLEANS PA</u> and SMITH <u>DE SOTO PA</u>; ROCK <u>KENAI-COOK INLET CD</u> and ROCK <u>ANCHORAGE CD</u>.

2. The name of a locality other than county, parish, or census division - Example: PIPE SAN ANTONIO and PIPE LACKLAND AFB.

The year the mark was set is considered extraneous to the designation and is not to be carried as a part of a control point name. For marks whose names were not altered when they were reset, the word RESET must be appended to the original designations. This also holds true for control points which have been reset more than once. In such cases the year given in the "year monumented" field of the description / recovery note will be used to distinguish the marks. See ANNEX D for additional information and examples.

Whenever the name of a horizontal control point is modified in this manner in the HZTL OBS data set for the purpose of making it unique within the respective job, the appended information becomes part of the station name, and care must be taken that exactly the same information is appended to the station name in the heading of the description and of all subsequent recovery notes which are given for that horizontal control point in the companion DESC data set (see Annex P).

When the lengthy name of a horizontal control point must be contracted to 30 characters, the abbreviation and/or editing of the station name in question should be accomplished with due regard to the following: First, a version up to 50 characters long of the station name is required in the DESC data set submitted concurrently with the HZTL OBS data set (see INTRODUCTION). This full or less drastically contracted version of the station name will be used for publication purposes. Second, the name may need to be shortened for the HZTL OBS data set. Names of reference and azimuth marks are normally formed by appending the symbols RM 1, RM 2, ..., RM 13, etc., and AZ MK (possibly AZ MK 2, AZ MK 3, etc.) to the name of the control point to which they belong. For this reason, the name of a horizontal control point which has reference marks and/or azimuth mark(s) may have to be contracted to 24 characters or less in order for the respective reference and azimuth mark names to conform to the 30-character limit.

Name or Designation of RM or AZ MK: Reference marks and azimuth marks are usually identified by standard disk markers which display an arrow as the survey point symbol at their center; the markers are set in such a way that the arrow points toward the associated horizontal control point. Two or more reference marks are normally established in the immediate vicinity of a monumented horizontal control point. The purpose of the reference mark is to act as a "pointer" to the related horizontal control point, thereby aiding in its recovery, and to provide a means of verifying whether or not the station monument has been disturbed. In addition to the reference marks, an azimuth mark may be established at some distance to provide an azimuth reference point which is visible from ground level. Less frequently, more than one azimuth mark is established for the same horizontal control point.

The originally established reference marks of a horizontal control point are normally assigned sequential numbers, e.g., NO 1, NO 2, etc. Any subsequently established reference mark should be assigned the next unused number in the sequence, even though one or more of the previously established reference marks may have been destroyed. The standard practice is to stamp the name of the horizontal control point to which a reference mark belongs above the arrow which appears in the center of the respective disk marker, the number of the reference mark (i.e., NO 1, NO 2, etc.) immediately below the arrow, and the year in which the reference mark was set farther below the arrow. The same procedure is followed in the case of an azimuth mark, except that a number is normally assigned and stamped on the respective disk marker only if more than one azimuth mark is involved.

The name or designation of a reference mark (RM) or an azimuth mark (AZ MK) entered on the *82* record must not exceed 30 characters in length. It should normally consist of the name of the horizontal control point to which the RM or AZ MK belongs, with the symbol RM 1, RM 2, ..., RM 13, etc. appended for reference marks NO 1, NO 2, ..., NO 13, etc. For azimuth marks, the symbol AZ MK is appended if only one azimuth mark is involved; otherwise the symbol AZ MK 2, AZ MK 3, etc. is used for azimuth marks NO 2, NO 3, etc. In general, nothing else should be added to the name of an RM or AZ MK, except when the numbering system outlined in the preceding paragraph has not been followed, with the result that two or more reference or azimuth marks associated with a horizontal control point are referred to by the same name.

Considering that the total length of an RM or AZ MK name must not exceed 30 characters, the name of the horizontal control point to which the RM 1, RM 2, etc., and/or AZ MK symbols are appended must be limited to 24 characters, and may have to be contracted further if a numeral follows the AZ MK symbol and/or the "year mark set" has to be added. The name of the respective horizontal control point must be taken as it appears on the corresponding *80* or *81* record (see <u>Station Name</u>), except for possible further abbreviation and/or editing which may be required.

The same general considerations apply to a reference or azimuth mark which is being treated as a control point (i.e., which is not regarded as a peripheral RM or AZ MK), whose 30-character name is to be entered on the respective *80* or *81* record. Occasionally, an existing monumented survey point of another agency is used for a reference mark or, more frequently, for an azimuth mark. Such a survey point must be treated as a control point, i.e., it must be identified by an SSN. If it can be positioned (or if its geodetic position is available from other sources), submit a *80* or *81* record for a control point of this kind; otherwise submit a *82* record to give its name or designation.

<u>Name or Designation of Bench Mark</u>: A bench mark (BM) is a monumented (or otherwise permanently marked) vertical control point whose height above mean sea level (MSL) has been determined by differential leveling. Bench marks occur in a horizontal control survey project if (1) a horizontal control point is also a BM in a line of differential leveling connected to the national vertical control network, (2) a spur level line connection exists between a horizontal control point and a nearby BM, or (3) a BM is included as a control point in the project for the purpose of extending vertical control by trigonometric leveling (vertical angles). All bench marks in a project should be positioned, if possible.

The name or designation of a bench mark entered on the *80* or *82* record must not exceed 30 characters in length. It should be taken as it appears in the heading of the bench mark description, which normally is identical to or closely resembles the name or designation stamped on the disk. If the name or designation of a bench mark must be contracted in order to conform to the 30-character limit, the same general considerations apply as for the abbreviation and/or editing of the name of a horizontal control point (see <u>Station Name</u> above).

If a reference mark disk (RM) for one control station is subsequently used as an azimuth mark for another control station, the name or designation of the mark should reflect the stamping on the mark (original use and not subsequent use).

Likewise, if a bench mark disk (BM) is used as a reference mark for a control station, the name or designation of the mark should always be that of the bench mark.

Geodetic Position: The geodetic position of every horizontal control point for which a *80* or *81* record is submitted must be given to serve either as a fixed position or as a preliminary position in the adjustment of the respective horizontal control survey project. The geodetic position may be expressed either in terms of geographic coordinates (latitude and longitude) on the *80* record, or it may be expressed in one of two plane coordinate systems - the Universal Transverse Mercator (UTM) coordinates, or the State Plane Coordinates (SPC) - on the *81* record.

The *80* record is intended for horizontal control points whose geodetic position is given in terms of geographic coordinates, i.e., as Latitude and Longitude. In addition to the numeric value (in sexagesimal degrees, minutes, seconds, and decimals of a second), the Direction of Latitude must be specified as "N" or "S", and the Direction of Longitude must be specified as "E" or "W", by a one-letter code adjacent to the latitude and longitude fields.

The *81* record is intended for horizontal control points whose geodetic position is given in terms of plane coordinates, i.e., as a Y-Coordinate (northing) and an X-Coordinate (easting), followed by a four-digit coordinate system zone designation. If Universal Transverse Mercator (UTM) coordinates are used, the northing and easting values are expected in meters and decimals of a meter. The zone designation must be the appropriate UTM Zone Number (0001-0060) as shown in ANNEX H. If State Plane Coordinates (SPC) are used, the northing and easting values are expected in meters and decimals of a meter. The zone designation must be the appropriate State Zone Code as given in ANNEX B.

Elevation and Elevation Code: Elevation is the vertical distance above the geoid - an equipotential surface. Along the sea coast the geoid closely follows mean sea level (MSL). Often referred to as "orthometric height," elevation is normally the dominant component of ellipsoidal height. Ellipsoidal height is the sum of elevation and geoid height. Geoid height is the name given to the vertical separation between the geoid and the reference ellipsoid of the geodetic datum used (NAD 83 or as specified on the *13* record). Ellipsoid heights of horizontal control points must be known or closely approximated for the purpose of reducing distance measurements to the reference ellipsoid and for computation of the skew normal and deflection corrections which are applied to horizontal directions and/or horizontal angles.

The elevation of every horizontal control point for which a *80* or *81* record is submitted must be given, except for unaccessible, unmonumented, recoverable landmarks positioned by intersection. When given, the elevation of such a landmark should be the ground level elevation (e.g., obtained from a topographic map, if a more accurate value is not available), and the height of the point actually sighted entered as the height of target on the respective observation record. But, since no distances are involved, the elevation field of an unaccessible landmark is preferred left blank.

The elevation of a survey point is determined most accurately by differential leveling. Other less accurate methods of determining the elevation of a survey point are (1) GPS observations, (2) trigonometric leveling using reciprocal vertical angles, (3) trigonometric leveling using non-reciprocal (i.e., one-sided) vertical angles, and (4) photogrammetric methods. In addition, an estimate of elevation based on the exponential decrease of atmospheric pressure with altitude can be obtained by a barometric leveling scheme (e.g., with the aid of an altimeter). As a last resort, if elevation from another source is not at hand, the approximate elevation can be obtained by interpolation between adjacent elevation contour lines on a map. In situations where ellipsoidal heights are known, the orthometric height can be computed by subtracting some estimate of the geoid height from the ellipsoidal height. Orthometric heights derived in this manner are coded using the "G" code. The geoid height value used in the computation must be submitted on a *86* record.

In every case, the source and general accuracy of the elevation value given on a *80*, *81*, or the preferred *86* record must be indicated by a one-letter <u>Orthometric Height (OHT) Code</u> (See table on page 2-84 for explanations). The possible elevation codes are as follows:

- A - The control point is a bench mark (BM) in the NGSIDB.
- B - BM determined using FGCS/NGS procedures but not in the NGSIDB.
- C - The control point is a 'posted' bench mark.
- D - OHT determined by datum transformation.
- F - OHT established using fly-leveling.
- G - OHT derived from GPS-observed heights with decimeter accuracy.
- H - OHT determined using FGCS procedures but tied to only one (1) BM.
- J - OHT derived from GPS-observed heights tied to meter accuracy control.
- K - OHT derived from GPS-observed heights, according to the 2cm/5cm ellipsoid height standards, and a high resolution national geoid model.
- L - OHT established using NGS leveling RESET procedures.
- M - OHT scaled from a topographic map.
- P - OHT determined by a photogrammetric method.
- R - OHT determined by reciprocal vertical angles.
- T - OHT determined by leveling between control points which are not BMs.
- V - OHT determined by non-reciprocal vertical angles.

<u>Station Order and Type</u>: A two-character field is reserved on the *80* and *81* records for the order-and-type code. The purpose of this code is to characterize the specific <u>order</u> of accuracy of the horizontal control point and to indicate whether the horizontal control point in question is monumented (or otherwise permanently marked), unmonumented but recoverable (e.g., a landmark), or unmonumented and non-recoverable (e.g., an auxiliary point). In addition, the purpose of this code is to characterize the <u>type</u> of the survey scheme of which the horizontal control point is a part and/or by means of which it is positioned (i.e., triangulation, trilateration, traverse, intersection, or resection). It also indicates whether the horizontal control point in question is considered to be a main-scheme station or a supplemental station in the respective survey scheme.

In every case, care must be taken to assign an order-and-type code which reflects how the horizontal control point was used in the project. For example, if a horizontal control point previously established as a first-order triangulation station is occupied in the course of a second-order traverse project, then it must be assigned an order-and-type code which classifies it as a second-order traverse station rather than as a first-order triangulation station. For control points which cannot be positioned within the project because of insufficient observations (but for which an accurate geodetic position is available from other sources, and hence for which a *80* or *81* record is submitted), the order-and-type code is to be left blank.

The first character (order) of the order-and-type code indicates the order of accuracy used to survey the main-scheme network. It reflects the surveying method used, procedures followed, and specifications enforced by the project instructions. It is also intended to indicate whether the horizontal control point is a monumented (or otherwise permanently marked) control point, an unmonumented recoverable landmark, or a temporary point, not permanently marked and therefore nonrecoverable, which must be treated as a control point (e.g., an unmarked eccentric point which is offset more than 10 meters from the respective control point). The respective "order codes" are as follows:

1. <u>Order Codes of Permanently Marked Stations</u>:

    A - Order A Interferometric Positioning
    B - Order B Interferometric Positioning
    0 - Trans-Continental Traverse (TCT)
    1 - First-Order Survey Scheme
    2 - Second-Order (Class I and Class II) Survey Scheme
    3 - Third-Order (Class I and Class II) Survey Scheme
    4 - Lower-Than-Third-Order Survey Scheme and
        Supplemental Unmonumented Recoverable Landmarks (see below).

2. <u>Order Codes of Nonrecoverable Points</u>:

    5 - First-Order Survey Scheme
    6 - Second-Order (Class I and Class II) Survey Scheme
    7 - Third-Order (Class I and Class II) Survey Scheme
    8 - Lower-Than-Third-Order Survey Scheme

In general, the order-and-type codes of all monumented (or otherwise permanently marked) horizontal control points should be assigned the same order code (equal to the order code of the order-and-class code assigned to the project - see p. 2-5 ff, <u>PROJECT DATA RECORDS</u>), except when survey work of more than one order-and-class category is included in the project. In this case, special care must be taken to assign the appropriate order code to every monumented control point according to the order-and-class category of the respective section of the project; control points which qualify for more than one order designation must be assigned the order code which corresponds to the <u>higher</u> order-and-class category. But, in a Trans-Continental Traverse (TCT) type project, only the stations of the high-precision traverse proper (i.e., stations connected by horizontal directions and by distances measured with electro-optical DME on two nights) should carry the order code "0"; other horizontal control points occupied and/or sighted upon should be treated as comparable stations in a first-order project.

As a matter of convention, the order code "4" is assigned to unmonumented recoverable landmarks positioned as supplemental stations, i.e., as intersections or spur traverse stations which are incidental to the primary survey scheme, regardless of the order-and-class category of the project or section of project of which they are a part. However, if such a landmark (e.g., a flagpole or church spire) occurs as an unoccupied main-scheme station in a triangulation network, then it must be assigned the same order code as any other main-scheme station in its vicinity, i.e., a main-scheme intersection station which is an unmonumented recoverable landmark must be assigned the same order code as a monumented control point.

Considering the discussion in the preceding two paragraphs, the allowable order codes of the order-and-type codes assigned to horizontal control points within a project (or within a section of a project) are as follows:

TABLE 2-5 - ALLOWABLE ORDER CODES

SURVEY SCHEME ORDER-AND-CLASS CATEGORY	ALLOWABLE ORDER CODES
Interferometric Positioning	A,B,1
Trans-Continental Traverse (TCT)	0,1,4,5
First-Order	1,4,5
Second-Order (Class I and Class II)	2,4,6
Third-Order (Class I and Class II)	3,4,7
Lower-Than-Third-Order	4,8

The second character (type) of the order-and-type code indicates the type of survey used to position the horizontal control point. It is also intended to indicate whether the horizontal control point is a main scheme station (i.e., one which is essential to the primary survey scheme) or a supplemental station (i.e., one which is incidental to the primary survey scheme). The respective "type codes" are as follows:

1. Type Codes of Main-Scheme Stations:

   1 - Positioned Primarily by Triangulation
   2 - Positioned Primarily by Trilateration
   3 - Positioned Primarily by Traverse
   A - Positioned Primarily by Interferometric Satellite Relative Positioning

2. Type Codes of Supplemental Stations:

   4 - Positioned Primarily by Triangulation
   5 - Positioned Primarily by Trilateration
   6 - Positioned Primarily by Traverse
   7 - Positioned by Intersection (Note: 1 if Main-Scheme Station)
   8 - Positioned by Resection
   B - Positioned Primarily by Interferometric Satellite Relative Positioning

As mentioned before, an intersection station which occurs as a main-scheme station (essential to the primary survey scheme) in a triangulation network is assigned the type code "1".

If it is not clear whether a horizontal control point is a main-scheme or supplemental station in a lst-Order or 2nd-Order (Class I or Class II) network, it should be treated as a main-scheme station. In particular, if special effort has been made to preserve the nominal accuracy of the respective main-scheme network in the positioning of a station which may not appear to be essential to the primary survey scheme (e.g., extra angular observations were taken and/or a distance was measured with electro-optical DME), such a supplemental station should be regarded as a main-scheme station and assigned a type code accordingly.

In a third-order and lower-than-third-order survey schemes, the distinction between main-scheme and supplemental stations is unimportant, hence type codes 4, 5, and 6 are not used with order codes 3 and 4; however, type codes 7 and 8 are still used to identify supplemental intersection and resection stations. In particular, the order-and-type code assigned to a recoverable landmark which is incidental to the survey scheme should be 47 if positioned by intersection (43 if positioned by a spur traverse) in a survey scheme of any order and class. Considering the discussion above, the allowable combinations of order and type codes that can be assigned to horizontal control points within a project (or within a section of a project) are as follows:

TABLE 2-6 - ALLOWABLE TYPE CODES

ORDER CODE	ALLOWABLE TYPE CODES
A	A
B	A,B
0	3,6
1,5	1,2,3,4,5,6,7,8,A,B
2,6	1,2,3,4,5,6,7,8,A,B
3,7	1,2,3,7,8,A
4,8	1,2,3,7,8,A

Whenever a horizontal control point qualifies for more than one type code (i.e., when a station can be considered to be positioned by two or more different survey methods), the type code which reflects the survey method resulting in the strongest position, when used alone, should be assigned. A hierarchy of order-and-type codes is given in ANNEX E.

Geoid Height: Geoid height is the name given to the vertical separation between the geoid and the reference ellipsoid of the geodetic datum used (NAD 83 or as specified on the *13* record). Along the sea coast the geoid, an equipotential surface, closely follows mean sea level (MSL). Elevation is the vertical distance above the geoid. Often referred to as "orthometric height," elevation is normally the dominant component of ellipsoidal height. Ellipsoidal height is the sum of elevation and geoid height. Ellipsoidal height must be known for every horizontal (and vertical) control point for the purpose of reducing horizontal control survey observations to the reference ellipsoid (and for the extension of vertical control by trigonometric leveling). Since the geoid height value associated with a horizontal (or vertical) control point is often unknown, it is a common practice to assume it to be zero, and hence to use the elevation as the best available approximation for the desired ellipsoidal height.

If a reliable value of geoid height is known, a *86* record should be submitted on which the respective geoid height is given in meters and decimals of meter. Note that the geoid height is <u>positive</u> when the geoid is <u>above</u> the ellipsoid and that it is <u>negative</u> when the geoid is <u>below</u> the ellipsoid. The geoid height value given should be accompanied by an estimate of its absolute accuracy in the form of a standard error (<u>Sigma</u>).

<u>Deflection of Vertical</u>: The deflection of vertical is the angle formed by the tangent to the direction of gravity (known as the "vertical") and the "normal" to the reference ellipsoid of the geodetic datum (NAD 83 or as specified on the *13* record). In addition to the magnitude of this angle, usually given in seconds and decimals of second of arc, the direction (e.g. the geodetic azimuth) of the deflection must also be specified. Alternatively, the direction of the deflection of vertical is implied when the deflection is given in terms of two rectangular components - e.g. the north-south or meridional component and the east-west or prime-vertical component.

The deflection of vertical comes into consideration in connection with horizontal directions, horizontal angles, and vertical angles observed with theodolites or transits which are leveled (i.e., oriented with respect to the direction of gravity). Accordingly, the deflection of vertical must be known at every point from which horizontal directions, horizontal angles, or vertical angles have been observed, so that appropriate corrections can be computed to convert these observed quantities from the gravity-oriented "astronomic" frame of reference to the ellipsoid-oriented geodetic system.

Because the deflection of vertical at a given horizontal control point is often unknown, it is a common practice to assume it to be zero. Since, in the continental United States, the maximum deflection of vertical, defined with respect to the North American 1983 datum (NAD 83), seldom exceeds 20 seconds of arc, and is normally much less (e.g., 3 to 5 seconds), the error introduced by this approximation in connection with the reduction of horizontal directions and horizontal angles is imperceptible except for long, inclined lines of sight in mountainous regions. However, in connection with the use of vertical angles for determining elevation differences, this approximation is one of the major sources of error which render the extension of vertical control by trigonometric leveling inaccurate.

If the deflection of vertical is reliably known (e.g., as a result of astronomic latitude and longitude observations), a *85* record should be submitted. The deflection is given in terms of the respective meridional (i.e., north-south) and prime-vertical (i.e., east-west) components, each expressed in seconds and decimals of second of arc.

The <u>Meridional</u> <u>Component</u> (Xi) of the deflection of vertical is the difference between the astronomic and geodetic latitudes of the horizontal control point. The direction of the meridional component, i.e., the <u>Direction</u> <u>of</u> <u>Xi</u> must be specified as "N" or "S" according to whether the astronomic latitude falls north or south of the corresponding geodetic latitude. The <u>Prime-Vertical</u> <u>Component</u> (Eta) of the deflection of vertical is the difference between the astronomic and geodetic longitudes of the horizontal control point, multiplied by the cosine of the approximate (astronomic or geodetic) latitude. The direction of the prime-vertical component, i.e., the <u>Direction</u> <u>of</u> <u>Eta</u> must be specified as "E" or "W" according to whether the astronomic longitude falls east or west of the corresponding geodetic longitude. Both the meridional and prime-vertical components of the deflection of vertical should be accompanied by an estimate of their absolute accuracy in the form of a standard error (Sigma).

The results of astronomic azimuth observations and astronomic position observations (recorded as the meridional and prime-vertical components of the deflection of vertical) are entered on the *60* and *85* records of the HZTL OBS data set. In addition, all astronomic latitude, longitude, and/or azimuth observations should be submitted separately in full detail for rigorous processing and incorporation into the astronomic data file of the National Geodetic Survey Data Base.

RECORD FORMATS

For each record which may appear in an HZTL OBS data set (see Table 2-1, p. 2-2), a field-by-field list follows which specifies and comments on the respective formats. Each record is 80 characters long and has a fixed format, i.e., every data field has a specific length and specific position within the record.

Required Data - In general, only those records which represent actual field observations collected during the survey project should be included in a HZTL OBS data set (e.g., omit *40*-series records if vertical angles were not observed). Data items within submitted records are required unless otherwise noted. Records or fields within records which are optional or which may be omitted under certain circumstances are so designated on the instruction sheet for each record type.

Alpha Field - 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 1 for a list of special characters which are allowed.

Blank Field - to be blank-filled; no data items allowed in these fields.

Constant (Numeric) Field - 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.

Floating Point Field (ff...fd..d) - intended for a data item which is coded as a decimal number, i.e., as a string of numeric characters (prefixed with minus sign if the number is negative) which may contain one leading, imbedded, or trailing period (the decimal point), but 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 a negative number is entered, code the minus sign immediately preceding the leading digit.

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. The coded decimal point overrides the implied decimal point position in every case.

Accordingly, a string of numeric characters representing m integer digits followed by n decimal fraction digits with an implied decimal point must be positioned in the floating-point field so that its integer part falls into the m rightmost “f” columns and its decimal fraction part into the n leftmost “d” columns, any unused columns of the data field being blank-filled.

Integer Field - intended for a data item which is coded as a string of numeric characters representing a positive or negative integer number, to be entered in 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.

Specific Character Field - intended to contain a specific alphabetic or numeric special character or a specific group of characters.

DATA SET IDENTIFICATION RECORD (*aa*)

The first record in a Horizontal Observation Data set must be a Data Set Identification Record which identifies the data class and type (HTZL OBS), the name of the submitting organization, and date the data set was created. The job code is a two-character alphanumeric code assigned to each horizontal control job submitted by an organization. An asterisk (*) immediately precedes and follows the code and the first character of the code must be a letter. Assign the code A1 to the first job and continue in sequence to the last. (A1, A2..., A9, B1, B2,...etc.) The job code used in this record must be identical to the job code in the Data Set Termination Record, the last record in the Horizontal Observation Data Set (HZTL OBS), and identical to the job code used in both the Data Set Identification Record and the Geodetic Control Point Descriptive (DESC) Data Set. This record is required.

aa FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. SHOULD BE 000010 IF USED IN THIS RECORD.
CC 07-10	JOB CODE. MUST BE *aa*. THE SYMBOL "aa" DENOTES THE TWO-CHARACTER CODE ASSIGNED BY THE SUBMITTING ORGANIZATION.
CC 11-14	DATA CLASSIFICATION. MUST BE HZTL.
CC 15-18	DATA TYPE. MUST BE OBS. LEFT JUSTIFIED.
CC 19-24	ABBREVIATION OF ORGANIZATION. SEE ANNEX C. IF NOT LISTED THERE, PROPOSED ABBREVIATION MUST BE ACCEPTED BY NGS PRIOR TO FIRST SUBMITTAL OF DATA. SEE ANNEX K.
CC 25-66	SUBMITTING ORGANIZATION. FULL NAME OR ORGANIZATION PERFORMING THE OBSERVATION. LEFT JUSTIFIED.
CC 67-72	ASSIGNED G/GPS NUMBER. (FOR NGS USE ONLY)
CC 73-80	DATE DATA SET CREATED. YEAR, MONTH, DAY (YYYYMMDD).

For a more detailed explanation of the contents of the record see Chapter 1, page 1-1, JOB CODE AND POINT NUMBERING and Chapter 2, pages 2-1 through 2-3, HZTL OBS DATA SET RECORDS.

PROJECT TITLE RECORD (*10*)

This record identifies the project by name. The use of geographic locality alone as the title of a horizontal control survey project has traditionally been the practice of NGS and its predecessors. This record is required.

10 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. SHOULD BE 000020 IF USED IN THIS RECORD.
CC 07-10	DATA CODE. MUST BE *10*.
CC 11-80	PROJECT TITLE. LEFT JUSTIFIED.

PROJECT TITLE CONTINUATION RECORD (*11*)

This record is required only if the project title in the *10* record exceeds the 70-character field allowed. Do not divide words between *10* and *11* records. This record is optional.

11 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *11*.
CC 11-80	PROJECT TITLE CONTINUED FROM *10* RECORD, IF NECESSARY.

For a more detailed explanation of the contents of this record see pages 2-5 and 2-6, PROJECT DATA RECORDS.

PROJECT INFORMATION RECORD (*12*)

This record identifies the person responsible for the survey (chief of party) by name, provides a record of the dates on which survey operations commenced and terminated, indicates type of survey, and order and class of survey. This record is required.

12 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *12*.
CC 11-16	DATE FIELD OPERATIONS BEGAN. YEAR, MONTH (YYYYMM).
CC 17-22	DATE FIELD OPERATIONS ENDED. YEAR, MONTH (YYYYMM).
CC 23-25	CHIEF OF PARTY INITIALS. (FIRST C.O.P.).
CC 26-43	SURNAME AND INITIALS OF CHIEF OF PARTY (FIRST C.O.P.) LEFT JUSTIFIED. SEPARATE SURNAME AND EACH INITIAL WITH A BLANK. DO NOT USE PERIODS OR OTHER SPECIAL CHARACTERS.
CC 44-46	CHIEF OF PARTY INITIALS. (SECOND C.O.P., IF ANY).
CC 47-64	SURNAME AND INITIALS OF SECOND CHIEF OF PARTY, IF ANY.
CC 65-75	BLANK
CC 76	SURVEY METHOD. IDENTIFY PRIMARY SURVEY METHOD USED. SEE TABLE BELOW.
CC 77-78	PRIMARY STATE OR COUNTRY CODE. SEE ANNEX A.
CC 79-80	ORDER AND CLASS OF SURVEY. SEE TABLE BELOW.

Survey Method Codes

1 - Triangulation

2 - Trilateration

3 - Traverse

4 - Global Positioning System

Order and Class of Survey Codes

AA - AA Order Interferometric Positioning
A0 - A Order Interferometric Positioning
B0 - B Order Interferometric Positioning
00 - Trans-Continental Traverse
10 - First Order
21 - Second Order Class I
22 - Second Order Class II
31 - Third Order Class I
32 - Third Order Class II
40 - Lower Than Third Order

For a more detailed explanation of the contents of this record see pages 2-5 through 2-7, PROJECT DATA RECORDS and DATE AND TIME.

GEODETIC DATUM AND ELLIPSOID RECORD (*13*)

This record defines the datum and reference ellipsoid for the geodetic positions, deflections of the vertical, geoid heights, and/or reduced ellipsoidal distances (Code E in *52* record) as they appear in this project. Do not enter the Inverse Flattening (1/f) if the ellipsoid is defined by the Semi-Major Axis (a) and the Semi-Minor Axis (b). Likewise, do not enter the Semi-Minor Axis (b) if the ellipsoid is defined by (a) and (1/f). This record is required unless the datum is the North American 1983 (NAD 83).

13 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *13*.
CC 11-34	DATUM NAME. DO NOT INCLUDE THE WORD 'DATUM' IN THE NAME. ABBREVIATE IF NECESSARY.
CC 35-50	NAME OF THE ELLIPSOID.
CC 51-60	SEMI-MAJOR AXIS (a) IN METERS (MMMMMMMmmm).
CC 61-70	INVERSE FLATTENING (1/f) (XXXxxxxxxx). THE FLATTENING (f) = (a - b) / a.
CC 71-80	SEMI-MINOR AXIS (b) IN METERS (MMMMMMMmmm).

HORIZONTAL DIRECTION SET RECORD (*20*)

This record identifies the initial direction for each set of direction observations. Use the Horizontal Direction Record (*22*) for all the remaining directions observed in the same set. The instrument station (standpoint) refers to the point from which the observation is taken (e.g., the point occupied by the observer). The target station (forepoint) refers to the point to which the observation is directed. Use the *21* Comment Record(s) immediately following the *20* record for any comments.

To anticipate the accuracy of an observation, the type of survey equipment used must be known. To identify the instrument used for each observation, assign a unique three-digit number (Job-Specific Instrument Number) in the range 001 to 999 to each item of survey equipment used in the job. Each number will cross reference a NGS survey equipment code in the *70* record. See Chapter 2, page 2-10, Job-Specific Instrument Number and page 2-28, Survey Equipment Data Records.

20 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *20*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT). FOR ADDITIONAL INFORMATION SEE CHAPTER 1, PAGES 1-1 THROUGH 1-3,JOB CODE AND SURVEY POINT NUMBERING; CHAPTER 2, PAGES 2-8 THROUGH 2-9, OBSERVATION DATA RECORDS; PAGES 2-12 THROUGH 2-13, ASSIGNMENT OF STATION SERIAL NUMBERS; AND PAGE 2-14, TREATMENT OF ECCENTRIC OBSERVATIONS.
CC 15-16	SET NUMBER. ENTER 01 FOR THE FIRST SET OF THE DIRECTION OBSERVATIONS. USE 02, 03, ETC. FOR SUCCESSIVE SETS. SEE CHAPTER 2, PAGE 2-18, SET NUMBER.
CC 17-22	FIELD RECORD BOOK NUMBER. VOLUME NUMBER ASSIGNED TO THE FIELD BOOK IN WHICH THE DIRECTION OBSERVATIONS ARE RECORDED.
CC 23-24	NUMBER OF OBJECTS SIGHTED IN THIS SET. THIS VALUE EQUALS THE SUM OF THE *20* RECORD AND THE *22* RECORD(S) IN THIS SET. SEE CHAPTER 2, PAGE 2-18.
CC 25-29	WEATHER CODE. THE FIRST COLUMN OF THIS CODE (25) IS A PROBLEM INDICATOR FOLLOWED BY VISIBILITY, TEMPERATURE, CLOUD COVER AND WIND INDICATORS IN SUCCESSION. FOR INFORMATION CONCERNING THE WEATHER CODE TO BE USED IN CONNECTION WITH HORIZONTAL OBSERVATIONS, SEE P. 2-10.
CC 30-32	INITIALS OF THE OBSERVER.
CC 33-35	JOB-SPECIFIC INSTRUMENT NUMBER (JSIN). THE UNIQUE THREE-DIGIT NUMBER IN THE RANGE 001 TO 999 ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS OBSERVATION. THIS NUMBER WILL CROSS REFERENCE THE NGS SURVEY EQUIPMENT CODE IN THE *70* RECORD.

CC 36-39	HEIGHT OF INSTRUMENT. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE OCCUPIED SURVEY MARK (POINT) TO THE OPTICAL CENTER OF THE SURVEYING INSTRUMENT. IN METERS (MMmm). FOR ADDITIONAL INFORMATION SEE CHAPTER 2, PAGE 2-11, <u>HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET</u>.
CC 40-45	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD). SEE CHAPTER 2, PAGES 2-18, <u>DATE AND TIME</u>.
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM). SEE CHAPTER 2, PAGE 2-7, <u>TIME</u>, AND PAGE 2-18, <u>DATE AND TIME</u>.
CC 50	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED. SEE CHAPTER 2, PAGE 2-7, <u>TIME ZONE</u>.
CC 51-54	SSN OF TARGET STATION. SEE CHAPTER 1, PAGES 1-1 THROUGH 1-3, <u>JOB CODE AND SURVEY POINT NUMBERING</u>; CHAPTER 2, PAGES 2-8 THROUGH 2-9, <u>OBSERVATION DATA RECORDS</u>; PAGES 2-12 THROUGH 2-13, <u>ASSIGNMENT OF STATION SERIAL NUMBERS</u>; AND PAGE 2-14, <u>TREATMENT OF ECCENTRIC OBSERVATIONS.</u>
CC 55-58	HEIGHT OF TARGET. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE TARGET STATION SURVEY MARK (POINT) TO THE TARGET (POINT)ABOVE THE MARK USED FOR THE DIRECTION OBSERVATIONS. IN METERS(MMmm). SEE CHAPTER 2, PAGE 2-11, <u>HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET</u>.
CC 59	VISIBILITY CODE. SEE CHAPTER 2, PAGE 2-11, <u>VISIBILITY CODE</u>.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF POINTINGS OR MEASUREMENTS USED TO DETERMINE A HORIZONTAL DIRECTION. SEE CHAPTER 2, PAGE 2-16, <u>NUMBER OF REPLICATIONS</u> AND PAGE 2-19, LAST PARAGRAPH.
CC 62-63	REJECTION LIMIT. THE MAXIMUM ALLOWED DEVIATION OF A SINGLE OBSERVATION FROM THE MEAN OF ALL THE OBSERVATIONS USED TO DETERMINE A DIRECTION IN A SET. IN SECONDS. SEE CHAPTER 2, PAGE 2-16, <u>REJECTION LIMIT</u>.
CC 64-72	INITIAL DIRECTION. MEAN OF POINTINGS OR MEASUREMENTS TO THE FIRST OBJECT SIGHTED IN THE OBSERVING SEQUENCE, NORMALLY ASSIGNED A VALUE ZERO DEGREES, ZERO MINUTES AND ZERO SECONDS (DDDMMSSss). SEE CHAPTER 2, PAGES 2-17 AND 2-18, <u>HORIZONTAL DIRECTION DATA RECORDS</u>.
CC 73-76	INTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE CHAPTER 2, PAGE 2-17, <u>INTERNAL CONSISTENCY SIGMA</u>.
CC 77-80	EXTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE CHAPTER 2, PAGE 2-17, <u>EXTERNAL CONSISTENCY SIGMA</u>.

For a more detailed discussion on accuracy, internal and external errors, see pages 2-15 through 2-17, <u>ACCURACY OF THE OBSERVATIONS</u>.

HORIZONTAL DIRECTION COMMENT RECORD (*21*)

Use this record for comments pertinent to the set of directions. This record is required to explain the problem encountered, if the problem indicator (Column 25) on the respective Horizontal Direction Set Record (*20*) is 1. Otherwise, this record is optional.

21 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *21*.
CC 11-80	COMMENT. IF THE COMMENT(S) EXCEED 70 CHARACTERS, USE ANOTHER *21* RECORD FOR CONTINUATION. ANY NUMBER OF *21* RECORDS IS ALLOWED. BUT, DO NOT DIVIDE WORDS BETWEEN CONSECUTIVE *21* RECORDS. SEE CHAPTER 2, PAGES 2-17 AND 2-18, HORIZONTAL DIRECTION DATA RECORDS.

HORIZONTAL DIRECTION RECORD (*22*)

Use this record for the second and subsequent directions observed in the same horizontal direction set. Use the Horizontal Direction Set Record (*20*) for the first direction (initial) observed in the set.

22 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *22*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT). MUST BE IDENTICAL TO THE SSN IN COLUMNS 11-14 ON THE RESPECTIVE *20* RECORD.
CC 15-16	SET NUMBER. MUST BE IDENTICAL TO THE SET NUMBER IN THE PRECEDING *20* RECORD.
CC 17-45	BLANK
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM). SEE PAGE 2-7 THROUGH 2-8, TIME.
CC 50	TIME ZONE. ENTER LETTER CODE FROM ANNEX H. SEE PAGE 2-7, TIME ZONE.
CC 51-54	SSN OF TARGET STATION (FOREPOINT). FOR ADDITIONAL INFORMATION SEE CHAPTER 1, PAGES 1-1 THROUGH 1-3, JOB CODE AND SURVEY POINT NUMBERING; CHAPTER 2, PAGES 2-8 THROUGH 2-9, OBSERVATION DATA RECORDS; PAGES 2-12 THROUGH 2-13, ASSIGNMENT OF STATION SERIAL NUMBERS; AND PAGE 2-14, TREATMENT OF ECCENTRIC OBSERVATIONS.
CC 55-58	HEIGHT OF TARGET. ENTER VERTICAL DISTANCE FROM THE TOP OF THE TARGET STATION SURVEY MARK (POINT) TO THE TARGET (POINT) ABOVE THE MARK, USED FOR THE DIRECTION OBSERVATIONS. IN METERS (MMmm). SEE CHAPTER 2, PAGE 2-11, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.
CC 59	VISIBILITY CODE. SEE PAGE 2-11, VISIBILITY CODE.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF POINTINGS OR MEASUREMENTS TO DETERMINE THIS OBSERVED DIRECTION. SEE CHAPTER 2, PAGE 2-16, NUMBER OF REPLICATIONS AND PAGE 2-19, LAST PARAGRAPH.
CC 62-63	REJECTION LIMIT. MAXIMUM ALLOWED DEVIATION FROM THE MEAN. IN SECONDS. SEE PAGE 2-16, REJECTION LIMIT.
CC 64-72	CLOCKWISE DIRECTION. MEAN OF POINTINGS OR MEASUREMENTS TO EACH OBJECT OBSERVED IN A SET. IN DEGREES, MINUTES, SECONDS (DDDMMSSss).
CC 73-76	INTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss) SEE PAGE 2-17, INTERNAL CONSISTENCY SIGMA.
CC 77-80	EXTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss) SEE PAGE 2-17, EXTERNAL CONSISTENCY SIGMA.

GPS OCCUPATION HEADER RECORD (*25*)

This record is used to define session information and the raw data file name at a station. There must be an occupation header record for each receiver in each session. Use the Comment Record (*26*) immediately following the *25* record for any comments.

To anticipate the accuracy of an observation, the type of survey equipment used must be known. To identify the instrument employed on each particular observation record in a concise manner, assign a unique three-digit number (Job-Specific Instrument Number) in the range 001 to 999 to each item of survey equipment used in the job. Each unique number will cross reference a NGS survey equipment code in the *70* record. See Chapter 2, page 2-10, Job-Specific Instrument Number and page 2-28, Survey Equipment Data Records. This record is required.

25 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *25*.
CC 11-14	SSN OF INSTRUMENT STATION. FOR ADDITIONAL INFORMATION SEE CHAPTER 1, PAGES 1-2 THROUGH 1-6, JOB CODE AND SURVEY POINT NUMBERING; CHAPTER 2, PAGES 2-8 THROUGH 2-9, OBSERVATION DATA RECORDS; PAGES 2-12 THROUGH 2-14, ASSIGNMENT OF STATION SERIAL NUMBERS; AND PAGE 2-14, TREATMENT OF ECCENTRIC OBSERVATIONS.
CC 15-24	DATA MEDIA IDENTIFIER. A CODE WHICH SPECIFICALLY DEFINES THE RECEIVER TYPE, DAY, YEAR, SESSION, AND STATION OBSERVED. FOR USE IN THE B-FILE AND G-FILE. SEE ANNEX L, PAGES L-1 AND L-2. THE FORMAT OF A DATA MEDIA IDENTIFIER IS: ADDDYSNNNN, WHERE: A IS THE CHARACTER WHICH INDICATES THE RECEIVER MANUFACTURER: A = ASHTECH, INC; C = TOPCON CORP; D = DEL NORTE TECHNOLOGY, INC; G = ALLEN OSBORNE ASSOCIATES, INC; I = ISTAC, INC; L = MINI-MAC™; M = Macrometer®; N = NORSTAR INSTRUMENTS, LTD; O = MOTOROLA, INC; R = TRIMBLE NAVIGATION, LTD; S = SERCEL, INC; T = TEXAS INSTRUMENTS, INC; W = LEICA HEERBRUGG AG-WILD HEERBRUGG-MAGNAVOX, INC; V = NOVATEL COMMUNICATIONS, LTD; X = OTHER; DDD IS THE DAY OF YEAR OF THE FIRST DATA EPOCH (UTC) Y IS THE LAST DIGIT OF THE YEAR OF THE FIRST DATA EPOCH S IS THE LETTER OR NUMBER OF THE SESSION OBSERVED NNNN IS THE PROJECT-UNIQUE, FOUR (4)-CHARACTER ABBREVIATION OF A STATION NAME.
CC 25-27	INITIALS OF THE OBSERVER
CC 28-30	JOB-SPECIFIC INSTRUMENT NUMBER. THE UNIQUE THREE-DIGIT NUMBER IN THE RANGE 001 TO 999 ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS OBSERVATION. THIS NUMBER WILL CROSS REFERENCE THE NGS SURVEY EQUIPMENT CODE IN THE *70* RECORD.
CC 31-32	LENGTH OF THE CABLE USED TO CONNECT RECEIVER AND ANTENNA. (XX) METERS.
CC 33-35	JOB-SPECIFIC ANTENNA NUMBER (JSAN). THE UNIQUE THREE-DIGIT NUMBER ASSIGNED TO THE ANTENNA USED TO OBTAIN THIS OBSERVATION. THIS NUMBER WILL CROSS REFERENCE THE NGS ANTENNA CODE IN THE *71*/*72* RECORD.
CC 36-80	BLANK

GPS OCCUPATION COMMENT RECORD (*26*)

Use this record for comments pertinent to the GPS occupation session. This record is optional.

26 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *26*.
CC 11-80	COMMENT. IF THE COMMENT(S) EXCEED 70 CHARACTERS, USE ANOTHER *26* RECORD FOR CONTINUATION. ANY NUMBER OF *26* RECORDS IS ALLOWED, BUT, DO NOT DIVIDE WORDS BETWEEN CONSECUTIVE *26* RECORDS.

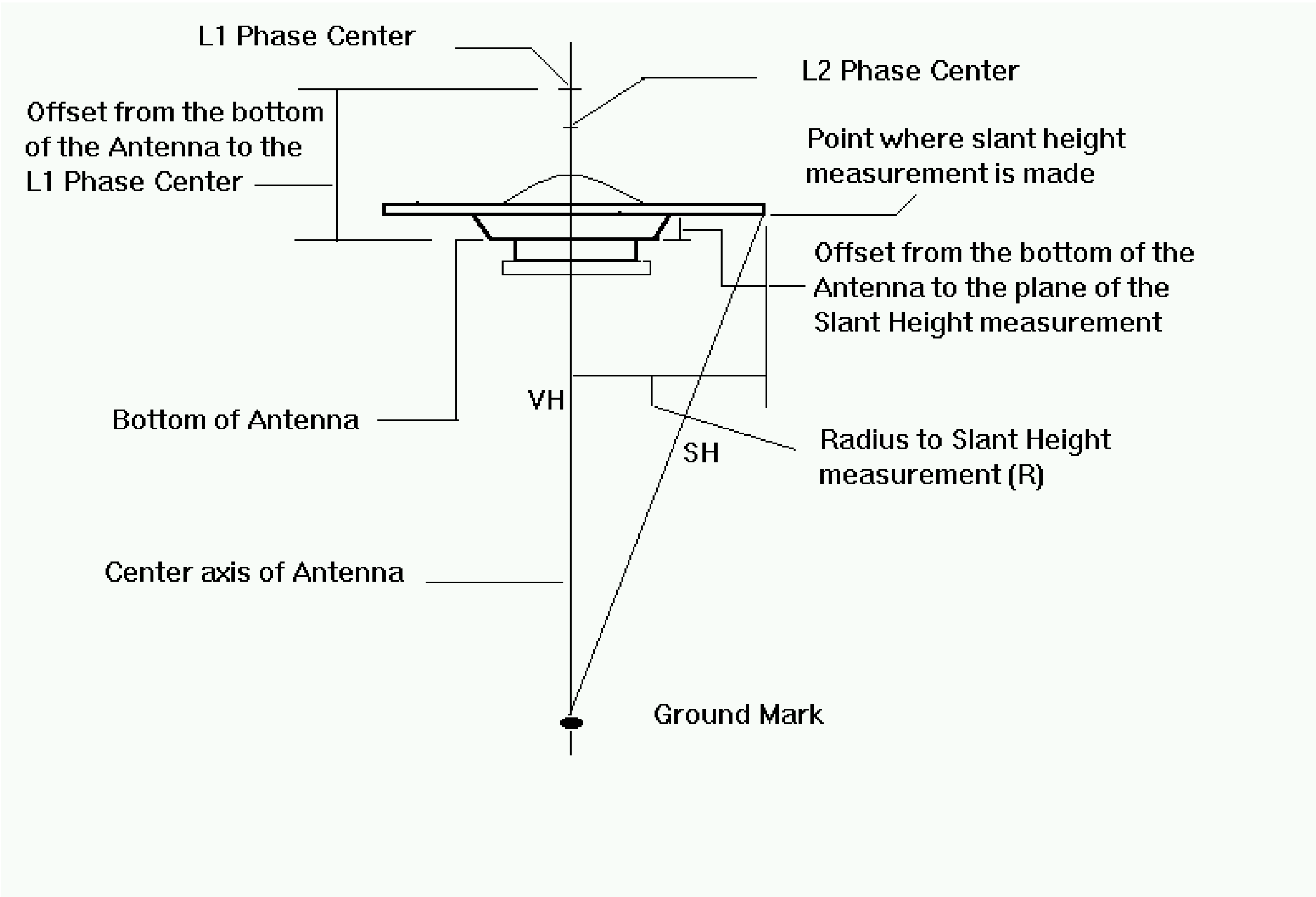
GPS OCCUPATION MEASUREMENT RECORD (*27*)

To identify the station occupied on each particular observation record in a concise manner, assign a unique four-digit number (Station Serial Number, SSN) in the range 0001 to 9999 to each station occupied in the job. Each SSN will cross-reference a survey station in an *80* record. See Chapter 1, page 1-1, Job Code and Survey Point Numbering and Chapter 2, page 2-12, Assignment of Station Serial Numbers. At least two *27* Records must be completed for each station in each session, i.e. one begin-session and one end-session record. A record for mid-session may be used. The antenna height can be measured from monument to either L1 Phase Center (L1PC) or Antenna Reference Point (ARP). It will be recorded in cc 25-29 if measured to L1PC and in cc 56-60 if measured to ARP. The ARP height will typically be 0.000 for CORS, as few CORS have a monument. The L1PC height is anticipated to be always non-zero.

These records are required.

27 FORMAT

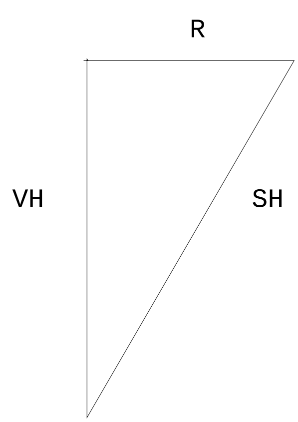
CC 01-06	SEQUENCE NUMBER. RIGHT JUSTIFIED. MUST BE AN INCREMENT OF 10 FROM PREVIOUS RECORD. OPTIONAL.
CC 07-10	DATA CODE. MUST BE *27*.
CC 11-14	STATION SERIAL NUMBER (SSN). INSTRUMENT STATION. FOR ADDITIONAL INFORMATION SEE CHAPTER 1, PAGES 1-2 THRU 1-6, JOB CODE AND SURVEY POINT NUMBERING; CHAPTER 2, PAGES 2-8 THRU 2-9, OBSERVATION DATA RECORDS; PAGES 2-12 THRU 2-13, ASSIGNMENT OF STATION SERIAL NUMBERS; AND PAGE 2-14, TREATMENT OF ECCENTRIC OBSERVATIONS.
CC 15-20	DATE OF OBSERVATION.(UTC) YEAR, MONTH, DAY (YYMMDD). SEE CHAPTER 2, PAGES 2-18, DATE AND TIME.
CC 21-24	TIME. HOURS, MINUTES (HHMM)(UTC). SEE CHAPTER 2, PAGE 2-7, TIME, AND PAGE 2-18, DATE AND TIME.
CC 25-29	HEIGHT OF THE L1 PHASE CENTER (L1PC) ABOVE THE MONUMENT (XX.xxx, implied decimal) IN METERS. SEE THE DIAGRAM ON PAGE 2-52a. OPTIONAL IF ARP HEIGHT IS RECORDED IN CC 56-60.
CC 30-33	DRY BULB TEMPERATURE (XXX.x). ALL REQUIRED WEATHER INFORMATION CAN BE FOUND ON THE METEOROLOGICAL DATA PORTION OF THE OBSERVER'S FIELD LOG. IT IS IMPORTANT TO MAKE SURE YOU ARE ENTERING DATA FOR THE CORRECT SESSION (BEGINNING AND ENDING READINGS).
CC 34	DRY BULB TEMPERATURE CODE (C/F). THE TEMPERATURE GIVEN MUST BE RECORDED IN CELSIUS OR FAHRENHEIT. NGS PREFERS CELSIUS.
CC 35-38	WET BULB TEMPERATURE (XXX.x). SEE DRY BULB TEMPERATURE.
CC 39	WET BULB TEMPERATURE CODE (C/F). SEE DRY BULB TEMPERATURE CODE.
CC 40-42	RELATIVE HUMIDITY (XX.x). ENTER THE PERCENTAGE OF RELATIVE HUMIDITY AT THE BEGINNING AND END OF THE SESSION.
CC 43-48	BAROMETRIC PRESSURE (XXXX.xx). (AT INITIATION AND COMPLETION) (ALLOWABLE UNITS MM, MB OR IN) THE BAROMETRIC PRESSURE CAN ALSO BE FOUND IN THE OBSERVER'S FIELD LOG.
CC 49-50	BAROMETRIC PRESSURE CODE. (MM, MB, IN) NGS PREFERS MB. MM - MILLIMETERS OF MERCURY MB - MILLIBARS IN - INCHES OF MERCURY
CC 51-55	WEATHER CODE. THE FIRST COLUMN OF THIS CODE (51) IS A PROBLEM INDICATOR FOLLOWED BY VISIBILITY, TEMPERATURE, CLOUD COVER AND WIND INDICATORS IN SUCCESSION. FOR INFORMATION CONCERNING THE WEATHER CODE TO BE USED IN CONNECTION WITH GEOMETRIC OBSERVATIONS, SEE CHAPTER 2, PAGES 2-10.
CC 56-60	HEIGHT OF THE ANTENNA REFERENCE POINT (ARP) ABOVE THE MONUMENT (xx.XXX with implied decimal) IN METERS. SEE DIAGRAM ON P. 2-52b. OPTIONAL IF L1PC HEIGHT IS RECORDED IN CC 25-29.
CC 61-80	BLANK



Radius to Slant Height Measurement (R): This is the horizontal distance from the vertical center axis of the antenna to the point where the slant height measurement (SH) is made.

Vertical Height (VH): This value, reduced from the slant height measurement by the formula below, is used in computing the required vertical height of the phase center (L1/L2) above the ground mark in the *27* record.

$$VH = \sqrt{SH^2 - R^2}$$

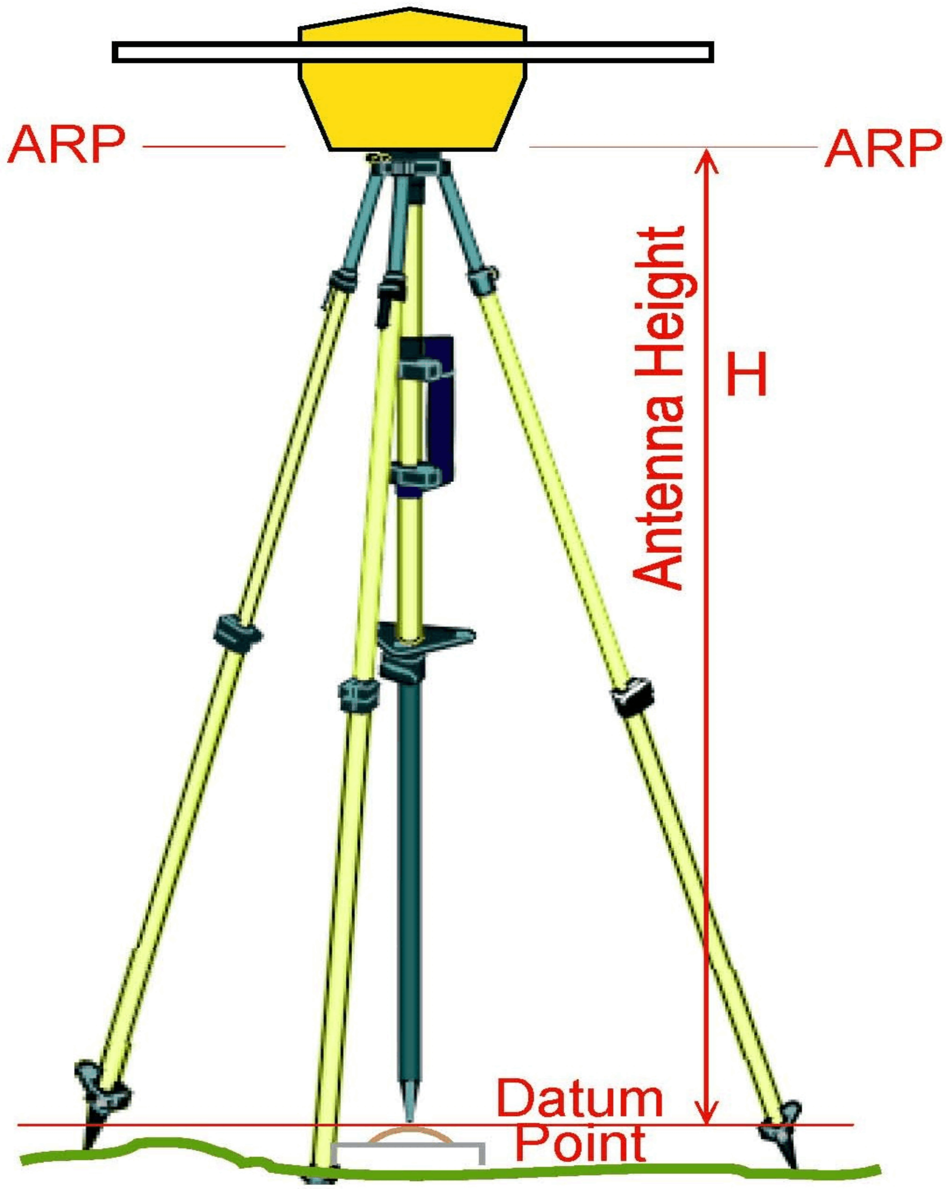


VH = Vertical Height as reduced from the slant height measurement.

R = Radius to the Slant Height Measurement.

SH = Slant Height Measurement.

The L1 Phase Center Offset used above is found in the Antenna Phase Pattern File.


ARP
ARP
Antenna Height
H
Datum
Point

GPS CLOCK SYNCHRONIZATION RECORD (*28)

The Clock Synchronization Record is used to record codeless type receiver clock synchronization information. Two records are normally created for each receiver per day, i.e., one pre-session and one post-session. Use the Comment Record (*29*) immediately following the *28* record for any comments. This record is required for codeless receivers.

28 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *28*.
CC 11-16	SYNCHRONIZATION DATE (YYMMDD) UTC. CODELESS TYPE GPS RECEIVERS MUST BE TIME SYNCHRONIZED WITH OTHER RECEIVERS IN THE SESSION.
CC 17-20	SYNCHRONIZATION TIME (HHMM) UTC. SEE SYNCHRONIZATION DATE.
CC 21-23	JOB-SPECIFIC INSTRUMENT NUMBER A. THE UNIQUE THREE-DIGIT NUMBER IN THE RANGE 001 TO 999 ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS OBSERVATION. THIS NUMBER WILL CROSS REFERENCE THE NGS SURVEY EQUIPMENT CODE IN THE *70* RECORD.
CC 24-26	JOB-SPECIFIC INSTRUMENT NUMBER B. SEE CC 21-23.
CC 27-31	BLANK
CC 32-36	TIMING DIFFERENCE (XXX.xx)(MICROSECONDS).
CC 37	INTEGER TIME SECOND SYNCH (Y OR N).
CC 38-40	INITIALS OF THE OBSERVER.
CC 41-80	BLANK

GPS CLOCK SYNCHRONIZATION RECORD (*29*)

Use this record for comments pertinent to the time synchronization of two or more GPS receivers. This record is optional.

29 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *26*.
CC 11-80	COMMENT. IF THE COMMENT(S) EXCEED 70 CHARACTERS, USE ANOTHER *29* RECORD FOR CONTINUATION. ANY NUMBER OF *29* RECORDS IS ALLOWED, BUT DO NOT DIVIDE WORDS BETWEEN CONSECUTIVE *29* RECORDS. SEE CHAPTER 2, PAGES 2-17 AND 2-18, <u>HORIZONTAL DIRECTION DATA RECORDS</u>.

HORIZONTAL ANGLE SET RECORD (*30*)

Use this record for the first angle of every set of angles observed at a station. Use the Horizontal Angle Record (*32*) for the remaining angles observed in the same set. Use a Comment Record (*31*) immediately following the *30* record for any comments pertaining to the set of observations.

To anticipate the accuracy of an observation, the type of survey equipment used must be known. To identify the instrument used for each observation, assign a unique three-digit number (Job-Specific Instrument Number) in the range 001 to 999 to each item of survey equipment used in the job. Each number will cross reference a NGS SURVEY EQUIPMENT CODE in the *70* record. See Chapter 2, Page 2-10, Job-Specific Instrument Number and Page 2-28, Survey Equipment Data Records.

30 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *30*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT). FOR ADDITIONAL INFORMATION SEE CHAPTER 1, PAGES 1-1 THROUGH 1-3, JOB CODE AND SURVEY POINT NUMBERING; CHAPTER 2, PAGES 2-8 THROUGH 2-9, OBSERVATION DATA RECORDS; PAGES 2-12 THROUGH 2-13, ASSIGNMENT OF STATION SERIAL NUMBERS; AND PAGE 2-14, TREATMENT OF ECCENTRIC OBSERVATIONS.
CC 15-16	SET NUMBER. ENTER 01 FOR THE FIRST SET OF ANGLE OBSERVATIONS. EACH ADDITIONAL SET OF ANGLES OBSERVED AT THE SAME STANDPOINT MUST BE ASSIGNED A HIGHER NUMBER: 02, 03, ETC. SEE CHAPTER 2, PAGE 2-20, SET NUMBER.
CC 17-22	FIELD RECORD BOOK NUMBER. VOLUME NUMBER OF THE FIELD BOOK IN WHICH THE ANGLES OBSERVATIONS ARE RECORDED.
CC 23-24	NUMBER OF ANGLES OBSERVED IN THIS SET. THIS NUMBER IS THE SUM OF THE *30* RECORD AND THE *32* RECORD (S) IN THIS SET. SEE CHAPTER 2, PAGE 2-20.
CC 25-29	WEATHER CODE. THE FIRST COLUMN OF THIS CODE (25) IS A PROBLEM INDICATOR FOLLOWED BY VISIBILITY, TEMPERATURE, CLOUD COVER AND WIND INDICATORS IN SUCCESSION. IF THE PROBLEM INDICATOR IS 1, A *31* RECORD IS REQUIRED. SEE CHAPTER 2, PAGE 2-10.
CC 30-32	INITIALS OF THE OBSERVER.
CC 33-35	JOB-SPECIFIC INSTRUMENT NUMBER (JSIN). THE UNIQUE THREE-DIGIT NUMBER IN THE RANGE 001 TO 999 ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS OBSERVATION. THIS NUMBER WILL CROSS REFERENCE THE NGS SURVEY EQUIPMENT CODE IN THE *70* RECORD.
CC 36-39	HEIGHT OF INSTRUMENT. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE OCCUPIED SURVEY MARK (POINT) TO THE OPTICAL CENTER OF THE SURVEYING INSTRUMENT. IN METERS (MMmm). SEE PAGE 2-11, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.

CC 40-45	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD). SEE CHAPTER 2, PAGE 2-20, <u>DATE AND TIME</u>.
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM) SEE CHAPTER 2, PAGE 2-7, <u>TIME</u>; AND PAGE 2-20, <u>DATE AND TIME</u>.
CC 50	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED. SEE CHAPTER 2, PAGE 2-7.
CC 51-54	SSN OF FIRST TARGET STATION (LEFT FOREPOINT). SEE CHAPTER 1, PAGES 1-1 THROUGH 1-3, <u>JOB CODE AND SURVEY POINT NUMBERING</u>; CHAPTER 2, PAGES 2-12 THROUGH 2-13, <u>ASSIGNMENT OF STATION SERIAL NUMBERS</u>; AND PAGE 2-14, <u>TREATMENT OF ECCENTRIC OBSERVATIONS</u>.
CC 55-58	HEIGHT OF TARGET. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE FIRST TARGET STATION (LEFT FOREPOINT) SURVEY MARK (POINT) TO THE TARGET (POINT) ABOVE THE MARK USED FOR THE ANGLE OBSERVATIONS. IN METERS (MMmm). SEE CHAPTER 2, PAGE 2-11, <u>HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET</u>.
CC 59	VISIBILITY CODE. SEE CHAPTER 2, PAGE 2-11, <u>VISIBILITY CODE</u>.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF DETERMINATIONS OF A SINGLE ANGLE MEASUREMENT WHICH ARE MEANED TO OBTAIN THE DESIRED ANGLE VALUE. EACH DETERMINATION OF A SINGLE ANGLE WILL USUALLY INVOLVE SEVERAL REPEATED MEASUREMENTS (REPETITIONS). SEE CHAPTER 2, PAGES 2-19 AND 2-20, <u>HORIZONTAL ANGLE DATA RECORDS</u>.
CC 62-63	REJECTION LIMIT. THE MAXIMUM ALLOWED DEVIATION OF A SINGLE ANGLE MEASUREMENT FROM THE MEAN OF ALL THE MEASUREMENTS USED TO DETERMINE THE DESIRED ANGLE IN A SET. SEE CHAPTER 2, PAGES 2-16.
CC 64-71	CLOCKWISE ANGLE. MEAN OF FIRST ANGLE OBSERVED AT A STATION. IN DEGREES, MINUTES, SECONDS (DDDMMSSs). SEE PAGES 2-19 AND 2-20, <u>HORIZONTAL ANGLE DATA RECORDS</u>.
CC 72-75	SSN OF SECOND TARGET STATION (RIGHT FOREPOINT). SEE PAGES 1-1 THROUGH 1-3, <u>JOB CODE AND SURVEY POINT NUMBERING</u>; PAGES 2-8 THROUGH 2-9, <u>OBSERVATION DATA RECORDS</u>; PAGES 2-12 THROUGH 2-13, <u>ASSIGNMENT OF STATION SERIAL NUMBERS</u>; AND PAGE 2-14, <u>TREATMENT OF ECCENTRIC OBSERVATIONS</u>.
CC 76-79	HEIGHT OF TARGET. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE SECOND TARGET STATION (RIGHT FOREPOINT) SURVEY MARK (POINT) TO THE TARGET (POINT) ABOVE THE MARK USED FOR THE ANGLE OBSERVATIONS. IN METERS (MMmm). SEE PAGE 2-11, <u>HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET</u>.
CC 80	VISIBILITY CODE. SEE <u>PAGE</u> 2-11, <u>VISIBILITY CODE</u>.

HORIZONTAL ANGLE COMMENT RECORD (*31*)

Use this record for comments pertaining to the set of angles. This record is required to explain the problem encountered if the problem indicator (column 25) on the respective Horizontal Angle Set Record (*30*) is "1". Otherwise, this record is optional.

31 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *31*.
CC 11-80	COMMENT. IF THE COMMENT(S) EXCEED 70 CHARACTERS, USE ANOTHER *31* RECORD FOR CONTINUATION. ANY NUMBER OF *31* RECORDS IS ALLOWED. BUT, DO NOT DIVIDE WORDS BETWEEN CONSECUTIVE *31* RECORDS. SEE CHAPTER 2, PAGES 2-19 AND 2-20, <u>HORIZONTAL ANGLE DATA RECORDS</u>.

HORIZONTAL ANGLE RECORD (*32*)

Use this record for the second and subsequent angles observed in the same set. Use a Horizontal Angle Set Record (*30*) for the first angle observed in the set.

32 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *32*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT). FOR ADDITIONAL INFORMATION REFER TO PAGES 1-1 THROUGH 1-3, 2-9 AND 2-12 THROUGH 2-13.
CC 15-16	SET NUMBER. MUST BE THE SAME NUMBER AS ON THE PRECEDING *30* RECORD.
CC 17-45	BLANK.
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM). SEE CHAPTER 2, PAGE 2-7, <u>TIME</u>; AND PAGE 2-20, <u>DATE AND TIME</u>.
CC 50	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H THAT REPRESENTS THE TIME ZONE OCCUPIED. SEE CHAPTER 2, PAGE 2-7.
CC 51-54	SSN OF FIRST TARGET STATION (LEFT FOREPOINT). SEE CHAPTER 1, PAGES 1-1 THROUGH 1-3, <u>JOB CODE AND SURVEY POINT NUMBERING</u>; CHAPTER 2, PAGES 2-12 THROUGH 2-13, <u>ASSIGNMENT OF STATION SERIAL NUMBERS</u>; AND PAGE 2-14, <u>TREATMENT OF ECCENTRIC OBSERVATIONS</u>.
CC 55-58	HEIGHT OF TARGET. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE FIRST TARGET STATION (LEFT FOREPOINT) SURVEY MARK (POINT)TO THE TARGET (POINT) ABOVE THE MARK USED FOR THE ANGLE OBSERVATIONS. IN METERS (MMmm). SEE CHAPTER 2, PAGE 2-11, <u>HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET</u>.
CC 59	VISIBILITY CODE. SEE CHAPTER 2, PAGE 2-11, VISIBILITY CODE.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF DETERMINATIONS OF A SINGLE ANGLE MEASUREMENT WHICH ARE MEANED TO OBTAIN THE DESIRED ANGLE VALUE. EACH DETERMINATION OF A SINGLE ANGLE WILL USUALLY INVOLVE SEVERAL REPEATED MEASUREMENTS (REPETITIONS). SEE CHAPTER 2, PAGES 2-19 AND 2-20, <u>HORIZONTAL ANGLE DATA RECORDS</u>.
CC 62-63	REJECTION LIMIT. THE MAXIMUM ALLOWED DEVIATION OF A SINGLE ANGLE MEASUREMENT FROM THE MEAN OF ALL THE MEASUREMENTS USED TO DETERMINE THE DESIRED ANGLE IN A SET. SEE CHAPTER 2, PAGE 2-16.
CC 64-71	CLOCKWISE ANGLE. MEAN OF FIRST ANGLE OBSERVED AT A STATION. IN DEGREES, MINUTES, SECONDS (DDDMMSSs). SEE PAGES 2-19 AND 2-20, <u>HORIZONTAL ANGLE DATA RECORDS</u>.
CC 72-75	SSN OF SECOND TARGET STATION (RIGHT FOREPOINT). SEE PAGES 1-1 THROUGH 1-3, <u>JOB CODE AND SURVEY POINT NUMBERING</u>; PAGES 2-8 THROUGH 2-9, <u>OBSERVATION DATA RECORDS</u>; PAGES 2-12 THROUGH 2-13, <u>ASSIGNMENT OF STATION SERIAL NUMBERS</u>; AND PAGE 2-14, <u>TREATMENT OF ECCENTRIC OBSERVATIONS</u>.

CC 76-79 HEIGHT OF TARGET. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE SECOND TARGET STATION (RIGHT FOREPOINT) SURVEY MARK (POINT) TO THE TARGET (POINT) ABOVE THE MARK USED FOR THE ANGLE OBSERVATIONS. IN METERS (MMmm). SEE PAGE 2-11, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.

CC 80 VISIBILITY CODE. SEE PAGE 2-11, VISIBILITY CODE.

VERTICAL ANGLE SET RECORD (*40*)

Use this record for the first vertical angle (VA) or zenith distance (ZD) observed in a set. Use the Vertical Angle Record (*42*) for the remaining vertical angles or zenith distances observed in the same set. Use a Comment Record (*41*) immediately following the *40* record for any comments. For additional information, refer to pages 2-21 through 2-23, VA/ZD Data Records.

To anticipate the accuracy of an observation, the type of survey equipment must be known. To identify the instrument used for each observation, assign a unique three-digit number (Job-Specific Instrument Number) in the range 001 to 999 to each item of survey equipment used in the job. Each unique number will cross reference a NGS Survey Equipment Code in the *70* record. See Page 2-10, Job-Specific Instrument Number and Page 2-28, Survey Equipment Data Records.

40 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *40*
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT).
CC 15-16	SET NUMBER. ENTER 01 FOR THE FIRST SET OF VA/ZD OBSERVATIONS. USE 02, 03, ETC. FOR SUCCESSIVE SETS. SEE PAGE 2-22, SET NUMBER.
CC 17-22	FIELD RECORD BOOK NUMBER. VOLUME NUMBER OF THE FIELD BOOK IN WHICH THE VA/ZD OBSERVATIONS ARE RECORDED.
CC 23-24	NUMBER OF VA OR ZD OBSERVATIONS IN THIS SET. THIS VALUE IS EQUAL TO THE SUM OF THE *40* RECORD AND THE *42* RECORD(S) IN THIS SET. SEE PAGE 2-22.
CC 25-29	WEATHER CODE. THE FIRST COLUMN OF THIS CODE (25) IS A PROBLEM INDICATOR FOLLOWED BY VISIBILITY, TEMPERATURE, CLOUD COVER AND WIND INDICATORS IN SUCCESSION. IF THE PROBLEM INDICATOR IS "1", A *41* RECORD IS REQUIRED. SEE PAGE 2-10, WEATHER CODE.
CC 30-32	INITIALS OF THE OBSERVER.
CC 33-35	JOB-SPECIFIC INSTRUMENT NUMBER. THE UNIQUE THREE-DIGIT NUMBER ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS OBSERVATION. SEE ABOVE.
CC 36-39	HEIGHT OF INSTRUMENT. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE OCCUPIED SURVEY MARK (POINT) TO THE OPTICAL CENTER OF THE SURVEYING INSTRUMENT. IN METERS (MMmm). SEE PAGE 2-11, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.
CC 40-45	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD). SEE PAGE 2-24, DATE AND TIME.
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM). SEE PAGES 2-7, TIME AND 2-24, DATE AND TIME.
CC 50	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED. SEE PAGE 2-7, TIME ZONE.
CC 51-54	SSN OF TARGET STATION (FOREPOINT).

CC 55-58	HEIGHT OF TARGET. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE TARGET STATION SURVEY MARK (POINT) TO THE TARGET (POINT) ABOVE THE MARK USED FOR THE VA/ZD OBSERVATION. IN METERS (MMmm). REFER TO PAGE 2-11, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.
CC 59	VISIBILITY CODE. SEE PAGE 2-11.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF POINTINGS OR MEASUREMENTS USED TO DETERMINE A VA OR ZD OBSERVATION. SEE PAGES 2-21 AND 2-22, VERTICAL ANGLE/ZENITH DISTANCE DATA RECORDS.
CC 62-63	REJECTION LIMIT. MAXIMUM ALLOWED SPREAD BETWEEN THE OBSERVATIONS. IN SECONDS (XXxx).
CC 64-71	VERTICAL ANGLE OR ZENITH DISTANCE. MEAN OF POINTINGS OR MEASUREMENTS TO THE FIRST OBJECT SIGHTED IN THE OBSERVING SEQUENCE. IN DEGREES, MINUTES, SECONDS (DDDMMSSs). LEAVE CC 71 BLANK IF VA OR ZD IS GIVEN TO THE NEAREST SECOND; LEAVE CC 69-71 BLANK IF IT IS GIVEN TO THE NEAREST MINUTE.
CC 72	ANGLE CODE. INDICATE TYPE OF VERTICAL ANGLE MEASURED. E= ELEVATION, D= DEPRESSION, Z= ZENITH DISTANCE. SEE PAGE 2-22, ANGLE CODE.
CC 73-76	INTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE PAGES 2-15 THROUGH 2-17, ACCURACY OF THE OBSERVATIONS.
CC 77-80	EXTERNAL CONSISTENCY. SIGMA IN SECONDS PER KILOMETER (SSss). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE PAGES 2-15 THROUGH 2-17, ACCURACY OF THE OBSERVATIONS.

VERTICAL ANGLE COMMENT RECORD (*41*)

Use this record for comments pertaining to the set of vertical angles or zenith distances. This record is required to explain the problem encountered when the problem indicator (column 25) on the preceding Vertical Angle Set Record (*40*) is "1". Otherwise, this record is optional.

41 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *41*.
CC 11-80	COMMENT. IF THE COMMENT(s) EXCEED 70 CHARACTERS, USE ANOTHER *41* RECORD FOR CONTINUATION. ANY NUMBER OF *41* RECORDS IS ALLOWED. BUT, DO NOT DIVIDE WORDS BETWEEN CONSECUTIVE *41* RECORDS.

VERTICAL ANGLE RECORD (*42*)

Use this record for the second and subsequent vertical angles (VAs) or zenith distances (ZDs) observed in the same set; use Vertical Angle Set Record (*40*) for the first vertical angle or zenith distance observed in the set. Refer to pages 2-22 through 2-24 for additional information.

42 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *42*
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT). MUST BE IDENTICAL TO THE SSN USED IN COLUMNS 11-14 ON THE RESPECTIVE *40* RECORD.
CC 15-16	SET NUMBER. MUST BE THE SAME NUMBER AS ON THE PRECEDING *40* RECORD.
CC 17-45	BLANK.
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM).
CC 50	TIME ZONE. ENTER THE LETTER CODE FORM ANNEX H.
CC 51-54	SSN OF TARGET STATION (FOREPOINT).
CC 55-58	HEIGHT OF TARGET. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE TARGET STATION SURVEY MARK (POINT) TO THE TARGET (POINT) ABOVE THE MARK USED FOR THE VA/ZD OBSERVATION. REFER TO PAGE 2-11, <u>HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET</u>.
CC 59	VISIBILITY CODE. SEE PAGE 2-11.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF POINTINGS OR MEASUREMENTS USED TO DETERMINE A VA OR ZD OBSERVATION. SEE PAGES 2-21 AND 2-22, <u>VERTICAL ANGLE/ZENITH DISTANCE DATA RECORDS</u>.
CC 62-63	REJECTION LIMIT. MAXIMUM ALLOWED SPREAD BETWEEN THE OBSERVATIONS. IN SECONDS (XXxx).
CC 64-71	VERTICAL ANGLE OR ZENITH DISTANCE. MEAN OF POINTINGS OR MEASUREMENTS TO THE FIRST OBJECT SIGHTED IN THE OBSERVING SEQUENCE. IN DEGREES, MINUTES, SECONDS (DDDMMSSs). LEAVE CC 71 BLANK IF VA OR ZD IS GIVEN TO THE NEAREST SECOND; LEAVE CC 69-71 BLANK IF IT IS GIVEN TO THE NEAREST MINUTE.
CC 72	ANGLE CODE. INDICATE TYPE OF VERTICAL ANGLE MEASURED. E= ELEVATION, D= DEPRESSION, Z= ZENITH DISTANCE. SEE PAGE 2-22, <u>ANGLE CODE</u>.
CC 73-76	INTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE PAGES 2-15 THROUGH 2-17, <u>ACCURACY OF THE OBSERVATIONS</u>.
CC 77-80	EXTERNAL CONSISTENCY. SIGMA IN SECONDS PER KILOMETER (SSss). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE PAGES 2-15 THROUGH 2-17, <u>ACCURACY OF THE OBSERVATIONS</u>.

DIFFERENCE OF ELEVATION RECORD (*45*)

Use this record for each observed difference of elevation obtained by spirit leveling or by other than the trigonometric method coded in the *40* through *42* records. Use the Difference of Elevation Continuation Record (*47*) to code additional data pertinent to the observation in the preceding *45* record. For any comments use the Difference of Elevation Comment Record (*46*). Refer to page 2-23, LEVEL DATA RECORDS, for additional information.

45 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *45*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT).
CC 15-16	BLANK.
CC 17-22	FIELD RECORD BOOK NUMBER. VOLUME NUMBER OF THE FIELD BOOK IN WHICH THE ELEVATION OBSERVATIONS ARE RECORDED.
CC 23-24	BLANK.
CC 25-29	WEATHER CODE. THE FIRST COLUMN OF THIS CODE (25) IS A PROBLEM INDICATOR FOLLOWED BY VISIBILITY, TEMPERATURE, CLOUD COVER AND WIND INDICATORS IN SUCCESSION. IF THE PROBLEM INDICATOR IS "1", A *46* RECORD IS REQUIRED. SEE PAGE 2-10, WEATHER CODE.
CC 30-32	INITIALS OF THE OBSERVER.
CC 33-35	JOB-SPECIFIC INSTRUMENT NUMBER. THE UNIQUE THREE-DIGIT NUMBER ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS OBSERVATION. REFER TO PAGES 2-10 AND 2-28.
CC 36-38	NUMBER OF LEVELING SETUPS. NUMBER OF TURNING POINTS USED TO OBTAIN THE ELEVATION DIFFERENCE OF THE SECTION OBSERVED.
CC 39	BLANK.
CC 40-45	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD).
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM). SEE PAGE 2-7, TIME AND 2-24, DATE AND TIME.
CC 50	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H TO INDICATE WHICH TIME ZONE WAS OCCUPIED. SEE PAGE 2-7.
CC 51-54	SSN OF TARGET STATION (FOREPOINT).
CC 55-58	BLANK.
CC 59	VISIBILITY CODE. SEE PAGE 2-11.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF MEASUREMENTS (LEVEL RUNNINGS) OF THE SAME SECTION. IF THE MEAN VALUE OF A FORWARD AND A BACKWARD LEVEL RUN OF THE SAME SECTION IS CODED AS A SINGLE OBSERVATION, THEN THE NUMBER OF REPLICATIONS SHOULD BE CODED AS 2.
CC 62-63	BLANK.
CC 64-72	DIFFERENCE OF ELEVATION. DIFFERENCE OF ELEVATION OBSERVED BETWEEN TWO MARKS (A SECTION). IN METERS (MMMMMmmmm). IF THE DIFFERENCE IS NEGATIVE, CODE THE MINUS SIGN (-) IMMEDIATELY PRECEDING THE LEFTMOST DIGIT AND BLANK FILL COLUMNS LEFT OF THE MINUS SIGN.
CC 73-76	ACCURACY OF LEVELING. SIGMA IN MILLIMETERS (XXxx). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE.
CC 77-80	LENGTH OF SECTION. DISTANCE BETWEEN THE TWO MARKS FOR WHICH THE ELEVATION DIFFERENCE WAS DETERMINED. IN KILOMETERS (XXxx).

DIFFERENCE OF ELEVATION COMMENT RECORD (*46*)

Use this record for comments pertaining to the difference of elevation observations. If the problem indicator (column 25) on the preceding Difference of Elevation Record (*45*) is "1", this record is required to explain the problem encountered. Otherwise, this record is optional.

46 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *46*
CC 11-80	COMMENT. IF THE COMMENT(S) EXCEED 70 CHARACTERS, USE ANOTHER *46* RECORD FOR CONTINUATION. ANY NUMBER OF *46* RECORDS IS ALLOWED. BUT, DO NOT DIVIDE WORDS BETWEEN CONSECUTIVE *46* RECORDS.

DIFFERENCE OF ELEVATION CONTINUATION RECORD (*47*)

Use this record to indicate the Job-Specific Instrument (JSI) Number of the leveling rod and the initials of the observing agency.

47 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *47*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT). MUST BE THE SAME SSN AS ON THE PRECEDING *45* RECORD.
CC 15-16	BLANK.
CC 17-54	BLANK.
CC 55-57	JOB-SPECIFIC INSTRUMENT (JSIN) NUMBER. THE UNIQUE THREE-DIGIT NUMBER ASSIGNED TO THE LEVEL ROD USED TO OBTAIN THIS OBSERVATION. REFER TO PAGES 2-10 AND 2-28.
CC 58-63	OBSERVING ORGANIZATION. USE THE ABBREVIATION FOUND IN ANNEX C WHICH IDENTIFIES THE ORGANIZATION THAT OBSERVED THE DIFFERENCE OF ELEVATION BETWEEN THE TWO MARKS. ANY ABBREVIATION NOT FOUND IN ANNEX C MUST BE APPROVED BY NGS PRIOR TO SUBMITTING THE DATA.
CC 64-80	BLANK.

TAPED DISTANCE RECORD (*50*)

Use this record for distances measured with either calibrated (standardized) or uncalibrated steel or invar tapes. Included are distances consisting of any number of segments taped horizontally, taped distances consisting of any number of segments which have all been individually reduced to a common horizontal reference surface (other than the sea level or the ellipsoid) and one-segment unreduced tape distances (less than or equal to one tape length) measured along a slope. Use the *52* record for taped distances reduced to sea level or geoid, to the ellipsoid, or to mark-to-mark. See pages 2-24 through 2-26, <u>DISTANCE DATA RECORDS</u>.

50 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *50*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT).
CC 15-19	WEATHER CODE. THE FIRST COLUMN OF THIS CODE (15) IS A PROBLEM INDICATOR FOLLOWED BY VISIBILITY, TEMPERATURE, CLOUD COVER AND WIND INDICATORS IN SUCCESSION. IF THE PROBLEM INDICATOR IS "1", A *55* RECORD IS REQUIRED. SEE PAGE 2-10, <u>WEATHER CODE</u>.
CC 20-22	INITIALS OF THE OBSERVER.
CC 23-25	JOB-SPECIFIC INSTRUMENT NUMBER. THE UNIQUE THREE-DIGIT NUMBER ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS OBSERVATION. REFER TO PAGES 2-10 AND 2-28.
CC 26-29	TAPE SUPPORT HEIGHT. IN METERS (MMmm). USED ONLY FOR A CODE "S" DISTANCE. ENTER THE VERTICAL HEIGHT OF THE TAPE SUPPORT (IF ANY) ABOVE THE INSTRUMENT STATION (STANDPOINT) MARK TO THE NEAREST CENTIMETER (cm).
CC 30-34	ELEVATION OF INSTRUMENT STATION (STANDPOINT). IN METERS (MMMMm). FOR A CODE "H" DISTANCE ENTER THE ELEVATION TO WHICH THE TAPED DISTANCE WAS REDUCED.
CC 35-40	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD).
CC 41-44	LOCAL TIME. HOURS, MINUTES (HHMM). SEE PAGES 2-7, <u>TIME</u> AND 2-25, <u>DATE AND TIME</u>.
CC 45	TIME ZONE. ENTER THE LETTER FROM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED. REFER TO PAGE 2-7, <u>TIME ZONE</u>.
CC 46-49	SSN OF TARGET STATION (FOREPOINT).
CC 50-53	TAPE SUPPORT HEIGHT. IN METERS (MMmm). USED ONLY FOR A CODE "S" DISTANCE. ENTER THE VERTICAL HEIGHT OF THE TAPE SUPPORT (IF ANY) ABOVE THE TARGET STATION (STANDPOINT) MARK TO THE NEAREST CENTIMETER (cm).
CC 54-58	DIFFERENCE OF ELEVATION. IN METERS (MMmm). USED ONLY FOR A CODE "S" DISTANCE. ENTER THE DIFFERENCE OF ELEVATION FROM MARK TO MARK WITH RESPECT TO THE INSTRUMENT STATION (STANDPOINT).
CC 59	VISIBILITY CODE. SEE BELOW OR PAGE 2-11.

CC 60-61 NUMBER OF REPLICATIONS. NUMBER OF COMPLETE MEASUREMENTS OR DETERMINATIONS USED TO CALCULATE THE MEAN TAPED DISTANCE CODED IN THIS RECORD.

CC 62-63 REJECTION LIMIT. IN MILLIMETERS (XX). MAXIMUM ALLOWED DEVIATION OF OBSERVATIONS FROM THE MEAN.

CC 64-72 CORRECTED TAPED DISTANCE. IN METERS (MMMMMmmmm). TAPED HORIZONTAL (CODE T), REDUCED TO HORIZONTAL (CODE H) OR SLOPE (CODE S) DISTANCE WITH STANDARDIZATION, CATENARY AND TEMPERATURE CORRECTIONS APPLIED AS APPLICABLE TO THE METHOD OF MEASUREMENT AND/OR EQUIPMENT USED.

CC 73 DISTANCE CODE. SEE BELOW OR PAGE 2-26.

CC 74-76 INTERNAL CONSISTENCY. SIGMA IN MILLIMETERS (XXx). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. REFER TO PAGES 2-15 THROUGH 2-17, ACCURACY OF THE OBSERVATIONS.

CC 77-80 EXTERNAL CONSISTENCY. SIGMA IN PARTS PER MILLION (XXXx). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE PAGE 2-25.

VISIBILITY CODES

Code	Description
R	TARGET STATION (FOREPOINT) IS A REFERENCE MARK
Z	TARGET STATION IS AN AZIMUTH MARK
V	TARGET STATION IS VISIBLE FROM THE GROUND
N	TARGET STATION IS NOT VISIBLE FROM THE GROUND

DISTANCE CODES

Code	Description
T	TAPED HORIZONTAL DISTANCE
H	TAPED SLOPE DISTANCE REDUCED TO HORIZONTAL
S	TAPED SLOPE DISTANCE (ONE TAPE LENGTH OR LESS)

UNREDUCED DISTANCE RECORD (*51*)

Use this record for slant-range distances less than 100 kilometers in length, measured with electronic distance-measuring equipment (DME). Included are line-of-sight instrument-to-reflector distances measured with electro-optical DME and master-to-remote distances measured with microwave DME. Precision or resolution of the measured distance must be 1 centimeter or better. Use *53* record for coarser resolution DME. Instrument and/or reflector calibration corrections and refraction correction are assumed to have been applied. See pages 2-24 through 2-26, DISTANCE DATA RECORDS.

51 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *51*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT).
CC 15-19	WEATHER CODE. SAME FORMAT AS THE *50* RECORD. SEE PAGE 2-10, WEATHER CODE.
CC 20-22	INITIALS OF THE OBSERVER.
CC 23-25	JOB SPECIFIC INSTRUMENT NUMBER (JSIN). THE UNIQUE THREE DIGIT NUMBER ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS OBSERVATION. REFER TO PAGES 2-10 AND 2-28 FOR DETAILED EXPLANATION.
CC 26-29	HEIGHT OF INSTRUMENT. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE OCCUPIED SURVEY MARK (POINT) TO THE OPTICAL CENTER OF THE SURVEYING INSTRUMENT. IN METERS (MMmm). SEE PAGE 2-11, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.
CC 30-34	BLANK
CC 35-40	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD).
CC 41-44	LOCAL TIME. HOURS, MINUTES (HHMM). SEE PAGES 2-7, TIME AND 2-25, DATE AND TIME.
CC 45	TIME ZONE. ENTER THE LETTER CODE FORM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED. REFER TO PAGE 2-7, TIME ZONE.
CC 46-49	SSN OF TARGET STATION (FOREPOINT).
CC 50-53	HEIGHT OF REFLECTOR. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE TARGET STATION SURVEY MARK TO THE REFLECTOR ABOVE THE MARK USED FOR THE DISTANCE OBSERVATION IN METERS (MMmm). REFER TO PAGE 2-11, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.
CC 54-58	BLANK
CC 59	VISIBILITY CODE. SEE PAGE 2-11 OR SEE TEXT FOR THE *50* RECORD FORMAT.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF COMPLETE MEASUREMENTS OR DETERMINATIONS USED TO CALCULATE THE MEAN CORRECTED SLANT-RANGE DISTANCE CODED IN THIS RECORD.
CC 62-63	REJECTION LIMIT. MAXIMUM ALLOWED DEVIATION OF OBSERVATIONS FROM THE MEAN VALUE. IN MILLIMETERS.
CC 64-72	CORRECTED SLANT-RANGE DISTANCE. IN METERS (MMMMMmmmm). CORRECTIONS FOR THE INSTRUMENT, REFLECTOR AND REFRACTION ARE ASSUMED APPLIED AS APPLICABLE TO THE METHOD OF MEASUREMENT AND/OR THE EQUIPMENT USED.
CC 73	DISTANCE CODE. MUST BE "S".

CC 74-76 INTERNAL CONSISTENCY. SIGMA IN MILLIMETERS (XXx). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. REFER TO PAGES 2-15 THROUGH 2-17, ACCURACY OF THE OBSERVATIONS.

CC 77-80 EXTERNAL CONSISTENCY. SIGMA IN PARTS PER MILLION (XXXx). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE PAGE 2-25.

REDUCED DISTANCE RECORD (*52*)

Use this record for distances of less than 100 kilometers in length, measured to a precision of 1 centimeter or better that have been reduced to sea level or the geoid (code G), to the ellipsoid (code E), or to mark-to-mark (code X). Use *54* record for coarser-precision distances. This record is intended for taped distances and distances measured with electronic DME. In every case, the distance given is assumed to be the appropriately reduced value corresponding to the mean of the respective sample of distance measurements to which all applicable corrections have been applied. Among the required data items on this record are the values of the elevations (and of the geoid heights, if applicable) which were used in the respective reduction process. These values may be different than those given on the corresponding *80*-series records.

52 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *52*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT).
CC 15-19	WEATHER CODE. SAME FORMAT AS *50* AND *51* RECORDS.
CC 20-22	INITIALS OF THE OBSERVER.
CC 23-25	JOB SPECIFIC INSTRUMENT NUMBER. THE UNIQUE THREE DIGIT NUMBER ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS MEASUREMENT. SEE PAGES 2-10 AND 2-28.
CC 26-29	GEOID HEIGHT. IN METERS (MMMm). VALUE USED IN THE REDUCTION PROCESS. LEAVE BLANK FOR CODE "G" DISTANCE. IF THE GEOID HEIGHT IS NEGATIVE, CODE THE MINUS SIGN (-) IMMEDIATELY PRECEDING THE LEFTMOST DIGIT AND BLANK FILL COLUMNS LEFT OF THE MINUS SIGN.
CC 30-34	ELEVATION OF THE INSTRUMENT STATION (STANDPOINT) MARK. RECORD THE VALUE USED IN THE REDUCTION PROCESS. IN METERS (MMMMm).
CC 35-40	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD).
CC 41-44	LOCAL TIME. HOURS, MINUTES (HHMM). SEE PAGE 2-7, TIME.
CC 45	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H WHICH APPLIES.
CC 46-49	SSN OF TARGET STATION (FOREPOINT).
CC 50-53	GEOID HEIGHT. IN METERS (MMMm). VALUE USED IN THE REDUCTION PROCESS. LEAVE BLANK FOR CODE "G" DISTANCE. IF THE GEOID HEIGHT IS NEGATIVE, CODE THE MINUS SIGN (-) IMMEDIATELY PRECEDING THE LEFTMOST DIGIT AND BLANK FILL COLUMNS LEFT OF THE MINUS SIGN.
CC 54-58	ELEVATION OF THE TARGET STATION (FOREPOINT) MARK. RECORD THE VALUE USED IN THE REDUCTION PROCESS. IN METERS (MMMMm).
CC 59	VISIBILITY CODE. SEE PAGE 2-12 OR THE TABLE BELOW.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF MEASUREMENTS USED TO CALCULATE THE MEAN REDUCED DISTANCE CODED IN THIS RECORD.
CC 62-63	REJECTION LIMIT. MAXIMUM ALLOWED DEVIATION OF MEASUREMENTS FROM THE MEAN VALUE. IN MILLIMETERS (XX).

CC 64-72	REDUCED DISTANCE. IN METERS (MMMMMmmmm). ENTER DISTANCE REDUCED TO SEA LEVEL OR THE GEOID (CODE G), TO THE ELLIPSOID (CODE E), OR TO MARK-TO-MARK (CODE X). DO NOT ENTER TO MORE DECIMAL PLACES THAN IS WARRANTED BY THE PRECISION OF THE OBSERVATION.
CC 73	DISTANCE CODE. SEE PAGE 2-26 OR THE TABLE BELOW.
CC 74-76	INTERNAL CONSISTENCY. SIGMA IN MILLIMETERS (XXx). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. REFER TO PAGES 2-15 THROUGH 2-17, ACCURACY OF THE OBSERVATIONS.
CC 77-80	EXTERNAL CONSISTENCY. SIGMA IN PARTS PER MILLION (XXXx). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE PAGE 2-25 AND PAGES 2-15 THROUGH 2-17, <u>ACCURACY OF THE OBSERVATIONS</u>.

VISIBILITY CODES

Code	Description
R	TARGET STATION (FOREPOINT) IS A REFERENCE MARK
Z	TARGET STATION IS AN AZIMUTH MARK
V	TARGET STATION IS VISIBLE FROM THE GROUND
N	TARGET STATION IS NOT VISIBLE FROM THE GROUND

REDUCED DISTANCE CODES

Code	Description
G	MEASURED DISTANCES REDUCED TO THE GEOID
E	MEASURED DISTANCES REDUCED TO THE ELLIPSOID
X	MEASURED DISTANCES REDUCED TO MARK-TO-MARK

UNREDUCED LONG LINE RECORD (*53*)

Use this record for instrument-to-instrument spatial-chord distances derived from long-range electronic DME observations (e.g., HIRAN), obtained by extra-terrestrial methods (e.g., VLBI), or for slant-range distances measured by coarse-resolution DME. This record is intended for measured distances of 100 kilometers and longer. Since long-line and/or course-resolution distance measurements do not normally exhibit any proportional relationship with the length of the line, the External Consistency Sigma on the *53* and *54* records is expressed in meters.

53 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *53*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT).
CC 15-22	BLANK
CC 23-25	JOB SPECIFIC INSTRUMENT NUMBER. THE UNIQUE THREE DIGIT NUMBER ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS MEASUREMENT. SEE PAGES 2-10 AND 2-28.
CC 26-29	HEIGHT OF INSTRUMENT (ANTENNA). IN METERS (MMmm). ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE INSTRUMENT STATION (STANDPOINT) MARK TO THE ACTUAL ORIGIN OF THE MEASURED DISTANCE ABOVE/BELOW THE MARK.
CC 30-34	BLANK
CC 35-40	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD).
CC 41-44	LOCAL TIME. HOURS, MINUTES (HHMM). SEE PAGE 2-25, <u>DATE AND TIME</u>.
CC 45	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED. REFER TO PAGE 2-7, <u>TIME ZONE</u>.
CC 46-49	SSN OF TARGET STATION (FOREPOINT).
CC 50-53	HEIGHT OF INSTRUMENT (ANTENNA). IN METERS (MMmm). ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE TARGET STATION (FOREPOINT) MARK TO THE ACTUAL TERMINAL POINT OF THE MEASURED DISTANCE ABOVE/BELOW THE MARK.
CC 54-58	BLANK
CC 59-60	NUMBER OF REPLICATIONS. NUMBER OF COMPLETE MEASUREMENTS USED TO CALCULATE THE MEAN CORRECTED SLANT-RANGE DISTANCE CODED IN THIS RECORD.
CC 61-63	REJECTION LIMIT. MAXIMUM ALLOWED DEVIATION OF OBSERVATIONS FROM THE MEAN VALUE. IN METERS (MMm).
CC 64-73	CORRECTED SPATIAL-CHORD DISTANCE. DERIVED INSTRUMENT-TO-INSTRUMENT (ANTENNA-TO-ANTENNA) SPACIAL-CHORD (CODE C) OR DIRECTLY-OBSERVED SLANT RANGE (CODE S) WITH ALL APPLICABLE CORRECTIONS APPLIED. IN METERS (MMMMMMMmmm).
CC 74	DISTANCE CODE. SEE ABOVE.
CC 75-77	INTERNAL CONSISTENCY. SIGMA IN METERS (Mmm). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. REFER TO PAGES 2-15 THROUGH 2-17, ACCURACY OF THE OBSERVATIONS.
CC 78-80	EXTERNAL CONSISTENCY. SIGMA IN METERS (Mmm). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE PAGE 2-25.

REDUCED LONG LINE RECORD (*54*)

Use this record for long lines, 100 kilometers and longer, or for any distances measured to a precision coarser than 1 centimeter, which have been reduced to sea level or the geoid (Code G), to the ellipsoid (Code E), or to mark-to-mark spatial-chord distance (Code X). Since the predominate external random errors associated with long-line and/or coarse-resolution distance measurements do not normally exhibit any proportional relationship with the length of the line, the External Consistency Sigma on the *53* and *54* records is expressed in meters.

54 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *54*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT).
CC 15-22	BLANK
CC 23-25	JOB SPECIFIC INSTRUMENT NUMBER. THE UNIQUE THREE DIGIT NUMBER ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS MEASUREMENT. SEE PAGES 2-10 AND 2-28.
CC 26-29	GEOID HEIGHT. IN METERS (MMMm). VALUE USED IN THE REDUCTION PROCESS FOR THE INSTRUMENT STATION (STANDPOINT). LEAVE BLANK FOR CODE G DISTANCE. IF THE GEOID HEIGHT IS NEGATIVE, CODE THE MINUS SIGN (-) IMMEDIATELY PRECEDING THE LEFTMOST DIGIT AND BLANK FILL THE COLUMNS LEFT OF THE MINUS SIGN.
CC 30-34	ELEVATION OF THE INSTRUMENT STATION (STANDPOINT) MARK. RECORD THE VALUE USED IN THE REDUCTION PROCESS. (POSSIBLY DIFFERENT THAN THE ELEVATION GIVEN ON THE CORRESPONDING *80* OR *81* RECORD. IN METERS (MMMMm).
CC 35-40	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD).
CC 41-44	LOCAL TIME. HOURS, MINUTES (HHMM).
CC 45	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED.
CC 46-49	SSN OF TARGET STATION (FOREPOINT).
CC 50-53	GEOID HEIGHT. IN METERS (MMMm). VALUE USED IN THE REDUCTION PROCESS FOR THE TARGET STATION (FOREPOINT). LEAVE BLANK FOR CODE G DISTANCE. IF THE GEOID HEIGHT IS NEGATIVE, CODE THE MINUS SIGN (-) IMMEDIATELY PRECEDING THE LEFTMOST DIGIT AND BLANK FILL THE COLUMNS LEFT OF THE MINUS SIGN.
CC 54-58	ELEVATION OF THE TARGET STATION (FOREPOINT) MARK. RECORD THE VALUE USED IN THE REDUCTION PROCESS (POSSIBLY DIFFERENT THAN THE ELEVATION GIVEN ON THE CORRESPONDING *80* OR *81* RECORD. IN METERS (MMMMm).
CC 59-60	NUMBER OF REPLICATIONS. NUMBER OF COMPLETE MEASUREMENTS USED TO CALCULATE THE MEAN REDUCED OBSERVATION CODED IN THIS RECORD.
CC 61-63	REJECTION LIMIT. MAXIMUM ALLOWED DEVIATION OF MEASUREMENTS FROM THE MEAN VALUE. IN METERS (MMm).

CC 64-73 REDUCED DISTANCE. IN METERS (MMMMMMMmmm). ENTER DISTANCE REDUCED TO SEA LEVEL OR THE GEOID (CODE G), TO THE ELLIPSOID (CODE E), OR TO MARK-TO-MARK (CODE X). DO NOT ENTER TO MORE DECIMAL PLACES THAN IS WARRANTED BY THE PRECISION OF THE OBSERVATION.

CC 74 DISTANCE CODE. ENTER THE APPROPRIATE G, E, OR X DESCRIBED ABOVE AND ON PAGE 2-28.

CC 75-77 INTERNAL CONSISTENCY. SIGMA IN METERS (Mmm). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. REFER TO PAGES 2-15 THROUGH 2-
17, ACCURACY OF THE OBSERVATIONS.

CC 78-80 EXTERNAL CONSISTENCY. SIGMA IN METERS (Mmm). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE PAGES 2-25 AND PAGES 2-15 THROUGH 2-17, ACCURACY OF THE OBSERVATIONS.

HORIZONTAL DISTANCE COMMENT RECORD (*55*)

Use this record for comments pertaining to the set of observed horizontal distances. This record is required to explain the problem encountered when the problem indicator (column 15) on the preceding Horizontal Distance Records (*50*, *51*, or *52*) is "1". Otherwise, this record is optional.

55 FORMAT

CC 01-06 SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.

CC 07-10 DATA CODE. MUST BE *55*.

CC 11-80 COMMENT. IF THE COMMENT(s) EXCEED 70 CHARACTERS, USE ANOTHER *55* RECORD FOR CONTINUATION. ANY NUMBER OF *55* RECORDS IS ALLOWED. BUT, DO NOT DIVIDE WORDS BETWEEN CONSECUTIVE *55* RECORDS.

ASTRONOMIC AZIMUTH/LAPLACE RECORD (*60*)

Submit this record for every astronomic azimuth observed in the project. If two or more sets of astronomic azimuth observations are taken (e.g., sets observed on different nights), submit a separate *60* record for each set.

The desired astronomic azimuth coded in this record is the mean value of the respective set of astronomic observations to which all applicable corrections have been applied.

A Laplace azimuth is an astronomic azimuth determination (from observations of a star) converted to the corresponding geodetic azimuth by the application of the Laplace correction (n * tan L). A data element necessary for the computation of a Laplace correction is the east-west (prime-vertical) component of the deflection of vertical (eta) at the respective instrument station (standpoint). Use the following formula to compute a Laplace azimuth:

$$G = A + n * \tan L$$

where :

G = geodetic azimuth (d,m,s)
A = astronomic azimuth (d,m,s)
n = eta (seconds)
L = geodetic latitude of the instrument station (standpoint)

If a reliable Eta value is unavailable, submit the *60* record with blanks in columns 15-19 and enter a code "A" in column 20 to designate the azimuth in columns 64-71 as Astronomic. Enter a code "L" in column 20 to designate the azimuth in columns 64-71 as Laplace, indicating that the Laplace correction has been applied.

60 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *60*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT).
CC 15-18	PRIME-VERTICAL COMPONENT OF DEFLECTION (ETA) VALUE USED IN LAPLACE CORRECTION. IN SECONDS (SSSs).
CC 19	DIRECTION OF ETA. ENTER CODE "E" FOR EAST OR CODE "W" FOR WEST.
CC 20	COMPUTATION CODE. ENTER CODE "A" FOR ASTRONOMIC OR CODE "L" FOR LAPLACE.
CC 21-29	BLANK
CC 30-32	INITIALS OF THE OBSERVER.
CC 33-35	JOB-SPECIFIC INSTRUMENT NUMBER. THE UNIQUE THREE-DIGIT NUMBER ASSIGNED TO THE INSTRUMENT USED TO OBTAIN THIS OBSERVATION. REFER TO PAGES 2-10 AND 2-28.
CC 36-39	HEIGHT OF INSTRUMENT. ENTER THE VERTICAL DISTANCE FROM THE TOP OF THE INSTRUMENT STATION (STANDPOINT) MARK TO THE OPTICAL CENTER OF THE SURVEYING INSTRUMENT. IN METERS (MMmm). SEE PAGE 2-11, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.

CC 40-45	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD).
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM). SEE PAGES 2-7, <u>TIME</u> AND 2-27, <u>DATE AND TIME</u>.
CC 50	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED. REFER TO PAGE 2-7, <u>TIME ZONE</u>.
CC 51-54	SSN OF TARGET STATION (FOREPOINT).
CC 55-58	HEIGHT OF TARGET. ENTER THE VERTICAL DISTANCE.
CC 59	VISIBILITY CODE. SEE PAGE 2-11.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF COMPLETE MEASUREMENTS OR DETERMINATIONS USED TO CALCULATE THE MEAN CORRECTED AZIMUTH OBSERVATION IN THIS RECORD.
CC 62-63	REJECTION LIMIT. MAXIMUM ALLOWED DEVIATION OF OBSERVATIONS FROM THE MEAN VALUE. IN SECONDS.
CC 64-71	ASTRONOMIC/LAPLACE AZIMUTH. DEGREES, MINUTES, SECONDS (DDDMMSSs). ASTRONOMIC AZIMUTH OBSERVATION (MEAN OF ONE SET) WITHOUT THE LAPLACE CORRECTION APPLIED (CODE A) OR WITH THE LAPLACE CORRECTION APPLIED (CODE L). <u>DO NOT APPLY</u> A SKEW NORMAL, GEODESIC, OR DEFLECTION CORRECTION.
CC 72	ORIGIN OF AZIMUTH. ENTER CODE "N" FOR NORTH OR CODE "S" FOR SOUTH.
CC 73-76	INTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss). ENTER ONLY IF A RELIABLE ESTIMATE IS AVAILABLE. REFER TO PAGES 2-15 THROUGH 2-17.
CC 77-80	EXTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss). ENTER ONLY IF A RELIABLE ESTIMATE IS AVAILABLE.

GEODETIC AZIMUTH RECORD (*61*)

Use this record for each computed geodetic azimuth used to orient this survey project. Record either a published azimuth to an azimuth mark from a previously established (published) control station that was occupied in this project, or geodetic azimuth obtained from an inverse position computation.

61 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *61*.
CC 11-14	SSN OF INSTRUMENT STATION (STANDPOINT).
CC 15-50	BLANK
CC 51-54	SSN OF TARGET STATION (FOREPOINT).
CC 55-63	BLANK
CC 64-71	GEODETIC AZIMUTH. DEGREES, MINUTES, SECONDS (DDDMMSSs).
CC 72	ORIGIN OF AZIMUTH. CODE "N" FOR NORTH OR CODE "S" FOR SOUTH.
CC 73-80	BLANK

INSTRUMENT RECORD (*70*)

Use this record to provide descriptive information for each item of survey equipment used in the job. This information will be used as an accuracy indicator for each observation in the survey. Assign a unique three-digit Job-Specific Instrument Number (JSIN) to each piece of equipment used in the project. This record will cross-reference the assigned JSIN to the NGS Survey Equipment Codes found in Annex F. More than one *70* record is required for any instrument used for more than one type of measurement. See page 2-28, <u>Survey Equipment Data Records</u>.

70 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *70*.
CC 11-13	JOB-SPECIFIC INSTRUMENT NUMBER (JSIN). MUST BE UNIQUE FOR EACH INSTRUMENT IN JOB. SEE PAGES 2-10 AND 2-28.
CC 14-16	NGS SURVEY EQUIPMENT CODE. SEE ANNEX F. USED TO IDENTIFY THE INSTRUMENT WHICH WAS ASSIGNED THE JSIN IN CC 11-13 ABOVE.
CC 17-20	RESOLUTION OF THE INSTRUMENT. RECORD THE SIZE OF THE SMALLEST DIRECTLY READABLE MEASUREMENT UNIT OR THE RESOLUTION PUBLISHED BY THE INSTRUMENT MANUFACTURER, WHICHEVER IS LARGER (XXxx).
CC 21-22	UNITS. UNITS OF THE RESOLUTION USED IN CC 17-20 ABOVE. SEE PAGE 2-28, <u>RESOLUTION OF THE INSTRUMENT AND UNITS</u>.
CC 23-40	MANUFACTURER OF THE INSTRUMENT. SEE ANNEX F. (EXAMPLES: WILD, ZEISS/JENA, HEWLETT PACKARD).
CC 41-62	TYPE OF INSTRUMENT OR TRADE NAME. SEE ANNEX F. (EXAMPLES; DIRECTION THEODOLITE, CALIB INVAR TAPE, RANGE MASTER, TELLUROMETER).
CC 63-70	MODEL OR CLASS OF INSTRUMENT. SEE ANNEX F. (EXAMPLES: T-3, MA-100, 30-MT, 100-FT).
CC 71-80	SERIAL NUMBER. ALPHANUMERIC AND LEFT JUSTIFIED. LEAVE BLANK IF THE SERIAL NUMBER IS NOT KNOWN.

NOTE: When this record is used to identify GPS equipment, colums 17-20, RESOLUTION OF THE INSTRUMENT, and colums 21-22, UNITS, should be left blank.

GPS ANTENNA RECORD (*71*)
(Superseded by *72*. See next page)

Use this record to provide descriptive information for each GPS antenna used in the job. Assign a unique three-digit Job-Specific Antenna Number (JSAN) to each GPS antenna used in the project. This record will cross-reference the assigned JSAN to the NGS GPS Antenna Codes found in Annex J. See pages 2-28 and 2-28a, <u>Survey Equipment Data Records</u>. Older data sets that have a *71* record will be accepted by NGS.

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *71*
CC 11-13	JOB SPECIFIC ANTENNA NUMBER (JSAN). MUST BE UNIQUE FOR EACH ANTENNA IN JOB.
CC 14-29	NGS ANTENNA CODE. SEE ANNEX J. USED TO IDENTIFY THE ANTENNA WHICH WAS ASSIGNED THE JSAN IN CC 11-13 ABOVE.
CC 30-41	SERIAL NUMBER. ALPHANUMERIC AND LEFT JUSTIFIED. LEAVE BLANK IF THE SERIAL NUMBER IS NOT KNOWN.
CC 42-53	ANTENNA PHASE PATTERN FILE. SEE PAGE 2-28a.
CC 54-59	SOURCE ORGANIZATION
CC 60-80	BLANK

GPS ANTENNA RECORD (*72*)
(Supersedes the *71* Record)

Use this record to provide descriptive information for each GPS antenna used in the job. Assign a unique three-digit Job-Specific Antenna Number (JSAN) to each GPS antenna used in the project. This record will cross-reference the assigned JSAN to the NGS GPS Antenna Codes found in Annex M. See pages 2-28 and 2-28a, Survey Equipment Data Records.

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *72*
CC 11-13	JOB SPECIFIC ANTENNA NUMBER (JSAN). MUST BE UNIQUE FOR EACH ANTENNA IN JOB.
CC 14-16	RESERVED
CC 17-36	NGS ANTENNA CODE. SEE ANNEX M. USED TO IDENTIFY THE ANTENNA WHICH WAS ASSIGNED THE JSAN IN CC 11-13 ABOVE.
CC 37-44	RESERVED
CC 45-64	SERIAL NUMBER. ALPHANUMERIC AND LEFT JUSTIFIED. LEAVE BLANK IF THE SERIAL NUMBER IS NOT KNOWN.
CC 65-80	BLANK

CONTROL POINT RECORD (*80*)

Use this record for the designation (name) and geographic position in geodetic coordinates (latitude and longitude) of each control point in the project.
If the position is given in Universal Transverse Mercator (UTM) coordinates or in State Plane Coordinates (SPC), use the *81* record. The geodetic position of every horizontal control point for which a *80* record is submitted must be provided in order to serve as either a fixed (constrained) position or as a preliminary position in the adjustment of the horizontal control survey project.

Columns 70-75 and column 76 of this record, formerly used for recording the elevation and elevation code, are now to be blank and the elevation put in the *86* record.

The first character of the order-and-type code indicates the order of accuracy of the main-scheme network in the project. It reflects the surveying methods used, procedures followed and specifications enforced to obtain the observations of the project.

The second character of the order-and-type code indicates the type of survey scheme of which the control point in question is a part and/or the (primary) surveying method used to position the control point. Refer to pages 2-35 through 2-38 for additional information.

80 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *80*.
CC 11-14	SSN. SEE PAGES 1-1, <u>JOB CODE AND SURVEY POINT NUMBERING</u> AND 2-12, <u>ASSIGNMENT OF STATION SERIAL NUMBERS</u>.
CC 15-44	STATION NAME. MUST NOT EXCEED 30 CHARACTERS. THE NAME OF A HORIZONTAL CONTROL POINT WITH PERIPHERAL REFERENCE MARKS AND/OR AZIMUTH MARKS MUST NOT EXCEED 24 CHARACTERS TO ALLOW FOR ADDING RM 1, RM 2, AND/OR AZ MK TO THE NAME WITHOUT EXCEEDING THE 30-CHARACTER LENGTH LIMIT.
CC 45-55	LATITUDE. DEGREES, MINUTES, SECONDS (DDMMSSsssss).
CC 56	DIRECTION OF LATITUDE. RECORD CODE "N" FOR NORTH OR CODE "S" FOR SOUTH.
CC 57-68	LONGITUDE. DEGREES, MINUTES, SECONDS, (DDDMMSSsssss).
CC 69	DIRECTION OF LONGITUDE. RECORD CODE "E" FOR EAST OR CODE "W" FOR WEST.

THE *86* RECORD IS TO BE USED FOR THE ELEVATION (ORTHOMETRIC HEIGHT) AND ELEVATION CODE, WHICH WERE FORMERLY DISPLAYED IN THE FOLLOWING TWO FIELDS.

CC 70-75	BLANK.
CC 76	BLANK.
CC 77-78	STATE OR COUNTRY CODE. IF THE CONTROL STATE IS LOCATED IN THE UNITED STATES/CANADA, ENTER THE CODE FROM ANNEX A FOR THE STATE/PROVINCE OR TERRITORY WHICH CONTAINS THE STATION. IF NOT, ENTER THE CODE FROM ANNEX A FOR THE COUNTRY WHICH CONTAINS THE STATION. SEE ANNEX A.
CC 79-80	STATION ORDER AND TYPE. REFER TO PAGES 2-35 THROUGH 2-38, <u>STATION ORDER AND TYPE</u> AND SEE ANNEX E.

CONTROL POINT (UTM/SPC) RECORD (*81*)

Use this record for the designation (name) and position in Universal Transverse Mercator (UTM) coordinates or in State Plane Coordinates (SPC) of each control point in the project. If the position is expressed in geodetic latitude and longitude, use the *80* record. The geodetic position of every horizontal control point for which a *81* record is submitted must be provided to serve as either a fixed (constrained) position or as a preliminary position in the adjustment of the horizontal control survey project.

NOTE: Columns 70-75 and column 76 of this record were formerly used for recording the elevation and elevation code; the elevation was generally presumed to be an orthometric height. With ellipsoid heights and geoid heights gaining importance, a change was made to accommodate the several types of height encountered in GPS processing: elevation data were moved to the *86* record. Elevations may still be entered in the *80* record, but they will be ignored by processing and checking programs.

81 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *81*.
CC 11-14	SSN. SEE PAGES 1-1, JOB CODE AND SURVEY POINT NUMBERING AND 2-12, ASSIGNMENT OF STATION SERIAL NUMBERS.
CC 15-44	STATION NAME. MUST NOT EXCEED 30 CHARACTERS. THE NAME OF A HORIZONTAL CONTROL POINT WITH PERIPHERAL REFERENCE MARKS AND/OR AZIMUTH MARKS MUST NOT EXCEED 24 CHARACTERS TO ALLOW FOR ADDING RM 1, RM 2, AND/OR AZ MK TO THE NAME WITHOUT EXCEEDING THE 30-CHARACTER LENGTH LIMIT.
CC 45-55	UTM/SPC NORTHING (Y COORDINATE). IN METERS (MMMMMMMMmmm).
CC 56-65	UTM/SPC EASTING (X COORDINATE). IN METERS (MMMMMMMmmm).
CC 66-69	UTM/SPC ZONE CODE.

THE *86* RECORD IS TO BE USED FOR THE ELEVATION (ORTHOMETRIC HEIGHT) AND ELEVATION CODE, WHICH WERE FORMERLY DISPLAYED IN THE FOLLOWING TWO FIELDS.

CC 70-75	ELEVATION. RECORD ELEVATION OF MARK ABOVE MEAN SEA LEVEL. IN METERS (MMMMmm). ENTER THE ELEVATION TO THE NEAREST CENTIMETER (cm). IF THE MEASUREMENT IS ONLY OBSERVED TO THE NEAREST DECIMETER (dm), LEAVE CC 75 BLANK, IF OBSERVED ONLY TO THE NEAREST METER (M), LEAVE CC 74-75 BLANK. REFER TO PAGES 2-34 and 2-35, ELEVATION AND ELEVATION CODE.
CC 76	ELEVATION CODE.
CC 77-78	STATE OR COUNTRY CODE. IF THE CONTROL STATE IS LOCATED IN THE UNITED STATES/CANADA, ENTER THE CODE FROM ANNEX A FOR THE STATE/PROVINCE OR TERRITORY WHICH CONTAINS THE STATION. IF NOT, ENTER THE CODE FROM ANNEX A FOR THE COUNTRY WHICH CONTAINS THE STATION. SEE ANNEX A.
CC 79-80	STATION ORDER AND TYPE. REFER TO PAGES 2-35 THROUGH 2-38, STATION ORDER AND TYPE. SEE ANNEX E.

REFERENCE, AZIMUTH OR OTHER DEPENDENT MARK RECORD (*82*)

Use this record to give the name or destination of each reference mark (RM) or azimuth mark (AZ MK). Follow each horizontal control point record, *80* or *81*, with as many *82* records as there are peripheral reference marks and/or azimuth marks associated with the horizontal control point in question. Distance, direction and/or angle observations to an RM or AZ MK must appear among the *20*-series (direction) and/or the 30*-series (angle) and the *50*-series (distance) observation records. <u>Do not</u> submit a *82* record for a RM or AZ MK which is being used as a horizontal control point (i.e., when the RM or AZ MK has an adjusted geodetic position or when the position is to be determined). Instead, submit a *80* or *81* record, identifying the station by its SSN.

Use this record in lieu of the *80* or *81* record for observed horizontal points to which direction, angle, and/or distance observations were made but which (1) cannot be positioned using data of this project alone, and (2) for which a position is not available from other sources.

For submitting unpositionable vertical control points, use the *82* record.

82 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *82*.
CC 11-14	SSN OF RM OR AZ MK. REFER TO PAGES 1-1 THROUGH 1-3, <u>JOB CODE AND</u> <u>SURVEY POINT NUMBERING</u> AND 2-12 THROUGH 2-13, <u>ASSIGNMENT OF STATION SERIAL NUMBERS</u>.
CC 15-44	NAME OF RM OR AZ MK. MUST NOT EXCEED 30 CHARACTERS. NORMALLY, THE NAME OF A RM OR AN AZ MK IS COMPOSED BY APPENDING "RM 1", "RM 2", ETC. OR "AZ MK" TO THE NAME OF THE CONTROL (PARENT) STATION REFERENCED. SEE PAGE 2-32, <u>NAME OR DESIGNATION OF RM OR AZ MK</u>.
CC 45-50	BLANK
CC 51-54	SSN OF THE PARENT STATION FOR WHICH THE STATION IDENTIFIED IN COLUMNS 11-14 IS A REFERENCE OR AZIMUTH MARK.
CC 55-80	BLANK

BENCH MARK RECORD (*83*)

Discontinued in favor of the *86* record

GEOID HEIGHT RECORD (*84*)

Discontinued in favor of the *86* record

DEFLECTION RECORD (*85*)

Use this record to give the source and the values of the meridional component (Xi) and/or prime-vertical component (Eta) of the deflection of vertical. The datum must be North American 1983 or as specified on the Datum and Ellipsoid (*13*) record. This record is optional.

85 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *85*.
CC 11-14	SSN OF HORIZONTAL CONTROL POINT.
CC 15-20	SOURCE. AGENCY OR ORGANIZATION WHICH DETERMINED THE DEFLECTION. USE THE ABBREVIATIONS LISTED IN ANNEX C OR THE ONE SPECIFIED ON THE DATA SET IDENTIFICATION RECORD (*aa*).
CC 21-61	COMMENT. USE THIS SPACE TO CLARIFY THE SOURCE OF THE DEFLECTION INFORMATION.
CC 62	DEFLECTION MODEL CODE. SEE THE LIST BELOW.
CC 63-67	MERIDIONAL COMPONENT (Xi) OF THE DEFLECTION OF VERTICAL. IN SECONDS (XXXxx).
CC 68	DIRECTION OF Xi. USE CODE "N" FOR NORTH OR CODE "S" FOR SOUTH.
CC 69-71	SIGMA. ESTIMATED ACCURACY (STANDARD ERROR) OF Xi. IN SECONDS (Xxx).
CC 72-76	PRIME-VERTICAL COMPONENT (Eta) OF THE DEFLECTION OF VERTICAL. IN SECONDS (XXXxx).
CC 77	DIRECTION OF Eta. USE CODE "E" FOR EAST OR CODE "W" FOR WEST.
CC 78-80	SIGMA. ESTIMATED ACCURACY (STANDARD ERROR) OF Eta. IN SECONDS (Xxx).

For a more detailed explanation of the contents of this record see pages 2-39 and 2-40, Deflection of Vertical.

DEFLECTION MODEL CODES:

Model Name	Code
DEFLEC99	A
DEFLEC90	C
DEFLEC93	H
DEFLEC96	J
DCAR97	L
POST NAD83 180 MODEL	M
DMEX97	N
NAD83 180 MODEL	P
360 MODEL	Q
PRE NAD83 DEFLECTION	T

ORTHOMETRIC HEIGHT, GEOID HEIGHT, ELLIPSOID HEIGHT RECORD (*86*)

Use this record to give the values of orthometric height, geoid height, and/or ellipsoid height of control points in this project.

For every Control Point Record (*80* or *81*), the orthometric height, commonly referred to as the elevation, of each control point should be provided, except for unmonumented recoverable landmarks positioned by intersection. For such landmarks, this record need not be submitted. However, when the elevation of an unmonumented recoverable landmark is given, it should be the orthometric height at ground level, and the height above ground level of the point actually sighted should be entered as the height of target on the respective observation record.

Ellipsoid height values are required for GPS projects. The geoid height is required if the orthometric height is determined from GPS observations (codes G, J, and K in the Table of Orthometric Height Codes listed on the following page). If values for the geoid height and/or ellipsoid height are provided, then the associated code for each is required.

The submitting organization may leave the orthometric height Order and Class code blank.

The Orthometric Height (OHT) NGSIDB Indicator field must be used to say whether the orthometric height came from the NGSIDB or not.

86 FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED. INCREMENT BY 10 FROM THE PREVIOUS RECORD.
CC 07-10	DATA CODE. MUST BE *86*.
CC 11-14	SSN OF CONTROL POINT.
CC 15-16	BLANK
CC 17-23	ORTHOMETRIC HEIGHT. IN METERS (MMMMmmm).
CC 24	ORTHOMETRIC HEIGHT CODE. SEE FOLLOWING TABLES.
CC 25-26	ORTHOMETRIC HEIGHT ORDER AND CLASS. USE PUBLISHED VERTICAL ORDER AND CLASS, OTHERWISE LEAVE BLANK.
CC 27	ORTHOMETRIC HEIGHT NGSIDB INDICATOR. SEE FOLLOWING TABLES.
CC 28-29	ORTHOMETRIC HEIGHT DATUM. SEE FOLLOWING TABLES.
CC 30-35	ORGANIZATION WHICH ESTABLISHED AND/OR MAINTAINS THE ORTHOMETRIC HEIGHT OF THE CONTROL POINT. ENTER THE ABBREVIATION LISTED IN ANNEX C OR ON THE DATASET IDENTIFICATION RECORD.
CC 36-42	GEOID HEIGHT. ABOVE (POSITIVE) OR BELOW (NEGATIVE) THE REFERENCE ELLIPSOID. IN METERS (MMMMmmm).
CC 43	GEOID HEIGHT CODE. SEE FOLLOWING TABLES.
CC 44-45	BLANK.
CC 46-52	ELLIPSOID HEIGHT. IN METERS (MMMMmmm).
CC 53	ELLIPSOID HEIGHT CODE. SEE FOLLOWING TABLES.
CC 54-55	ELLIPSOID HEIGHT ORDER AND CLASS. SEE ANNEX G.
CC 56	ELLIPSOID HEIGHT DATUM. SEE TABLE, P. 2-85.
CC 57-80	COMMENTS.

ORTHOMETRIC HEIGHT (OHT) NGSIDB INDICATOR

CODE	EXPLANATION
Y	OHT OBTAINED FROM THE NGSIDB.
N	OHT IS NOT IN THE NGSIDB.

TABLE OF ORTHOMETRIC HEIGHT (OHT) CODES

CODE	EXPLANATION
A	OHT ESTABLISHED USING FGCS LEVELING SPECIFICATIONS AND PROCEDURES, ADJUSTED HEIGHT DETERMINED USING NGS VERTICAL NETWORK BRANCH PROCEDURES, LEVELING DATA ARE IN THE NGSIDB.
B	OHT ESTABLISHED USING FGCS LEVELING SPECIFICATIONS AND PROCEDURES, ADJUSTED HEIGHT DETERMINED USING NGS VERTICAL NETWORK BRANCH PROCEDURES, LEVELING DATA ARE NOT IN THE NGSIDB. (USGS, COE, SOME STATE DOT DATA.)
C	OHT ESTABLISHED USING FGCS LEVELING SPECIFICATIONS AND PROCEDURES, ADJUSTED HEIGHT IS 'POSTED'. SEE EXPLANATION IN THE FOOTNOTE (*) BELOW.
D	OHT ESTABLISHED BY DATUM TRANSFORMATIONS.
F	OHT ESTABLISHED BY FLY-LEVELING.
G	OHT ESTABLISHED FROM GPS-OBSERVED HEIGHTS WITH DECIMETER ACCURACY.
H	OHT ESTABLISHED USING FGCS LEVELING SPECIFICATIONS AND PROCEDURES EXCEPT FOR THE TWO-MARK LEVELING TIE REQUIREMENT. (HORIZONTAL FIELD PARTY LEVEL TIES, SOME STATE DOTS, SOME GPS LEVEL TIES.)
J	OHT ESTABLISHED FROM GPS-OBSERVED HEIGHTS TIED TO METER ACCURACY CONTROL.
K	OHT ESTABLISHED FROM GPS-OBSERVED HEIGHTS, ACCORDING TO THE 2CM/5CM ELLIPSOID HEIGHT STANDARDS AND A HIGH RESOLUTION NATIONAL GEOID MODEL.
L	OHT ESTABLISHED USING LEVELING RESET SPECIFICATIONS AND PROCEDURES.
M	OHT ESTABLISHED BY SCALING FROM A CONTOURED MAP.
P	OHT ESTABLISHED BY PHOTOGRAMMETRY.
R	OHT ESTABLISHED BY RECIPROCAL VERTICAL ANGLES.
T	OHT ESTABLISHED BY LEVELING BETWEEN CONTROL POINTS WHICH ARE NOT BENCH MARKS.
V	OHT ESTABLISHED BY NON-RECIPROCAL VERTICAL ANGLES.

* DATA FOR LEVEL LINES CONTAINING 'POSTED' BENCH MARKS WERE PURPOSELY NOT INCLUDED IN THE NAVD88 GENERAL ADJUSTMENT. SUBSEQUENTLY, THESE DATA WERE ADJUSTED TO NAVD88 BY FORCING THEM TO FIT THE EXISTING NAVD88 GENERAL ADJUSTMENT HEIGHTS.

TABLE OF ORTHOMETRIC HEIGHT (OHT) DATUMS

CODE	EXPLANATION
29	NATIONAL GEODETIC VERTICAL DATUM OF 1929
88	NORTH AMERICAN VERTICAL DATUM OF 1988
55	INTERNATIONAL GREAT LAKES DATUM OF 1955
85	INTERNATIONAL GREAT LAKES DATUM OF 1985
AS	AMERICAN SAMOA DATUM OF 2002
LT	LOCAL TIDAL DATUM
NM	NORTHERN MARIANAS VERTICAL DATUM OF 2003
PR	PUERTO RICO VERTICAL DATUM OF 2002
VI	VIRGIN ISLANDS VERTICAL DATUM OF 2009
00	(zero zero) ANY OTHER DATUM. SPECIFY IN COMMENTS.

TABLE OF GEOID HEIGHT (GHT) CODES

CODE	EXPLANATION		
P	OSU78 GEOID MODEL	F	G96SSS GEOID MODEL
Q	OSU86F GEOID MODEL	G	EGM96 GEOID MODEL
B	OSU89B GEOID MODEL	H	CARIBBEAN GEOID MODEL
C	GEOID90 GEOID MODEL	J	MEXICO97 GEOID MODEL
D	GEOID93 GEOID MODEL	T	GEOID99
E	GEOID96 GEOID MODEL	U	G99SSS
V	GEOIDX–US HYBRID GEOID	W	GEOID03
X	USGG2003	Y	GEOID06
Z	USGG2006	1	USGG2009
2	GEOID09	3	EGM08
4	USGG2012	5	GEOID12A

TABLE OF ELLIPSOID HEIGHT (EHT) CODES

CODE	EXPLANATION
A	EHT DETERMINED BY GPS IN A HIGH PRECISION GEODETIC NETWORK OR TIED TO A HIGH PRECISION GEODETIC NETWORK (HPGN).
B	EHT DETERMINED BY GPS NOT TIED TO A HPGN.
C	EHT DETERMINED BY ADDING A GEOID HEIGHT TO AN ORTHOMETRIC HEIGHT WITH AN OHT CODE OF A, B, C, F, H, OR L.
D	EHT DETERMINED BY ADDING A GEOID HEIGHT TO AN ORTHOMETRIC HEIGHT WITH AN OHT CODE OF G, R, OR T.
E	EHT DETERMINED BY ADDING A GEOID HEIGHT TO AN ORTHOMETRIC HEIGHT WITH AN OHT CODE OF V, M, P, OR D.

TABLE OF ELLIPSOID HEIGHT (EHT) DATUMS
ALL ARE REFERENCED TO GRS80 ELLIPSOID EXCEPT POSSIBLY Z

CODE	EXPLANATION
A	NORTH AMERICAN DATUM OF 1983
B	INTERNATIONAL TERRESTRIAL REFERENCE FRAME OF 1989
C	NATIONAL EARTH ORIENTATION SERVICE (NEOS ANNUAL REPORT FOR 1990)
D	INTERNATIONAL TERRESTRIAL REFERENCE FRAME OF 1994 (ITRF 94)
E	INTERNATIONAL TERRESTRIAL REFERENCE FRAME OF 1996 (ITRF 96)
F	INTERNATIONAL TERRESTRIAL REFERENCE FRAME OF 1997 (ITRF 97)
G	INTERNATIONAL TERRESTRIAL REFERENCE FRAME OF 2000 (ITRF 00)
Z	ANY OTHER DATUM. SPECIFY IN COMMENTS.

FIXED CONTROL RECORD (*90*)

Discontinued. Ignored but not a problem if included in the blue book file (HZTL OBS data set).

Network Accuracy Record (*91*)

The network accuracy record is computed by the adjustment software and inserted into the bluebook output file. The network accuracy of a control point is a value that represents the uncertainty of its coordinates with respect to the geodetic datum. The north, east, and ellipsoid height standard deviations for this record are stored in cm at approximately 68.3% confidence ("one sigma").

Columns	*Field Name*	*Field Format*	*Field Range*	*Field Description/Comments*
01-06	Sequence Number	999999	000001-999999	Optional.
07-10	Data Code	A99A	*91*	Record identifier.
11-14	SSN (Station Serial Number) of Control Point	9999	0001..9999	A number which uniquely identifies a station within a project.
15-20	BLANK			Spacer.
21-30	North Horizontal Standard Deviation	9999999.99	0.00..9999999.99	Horizontal accuracy/standard deviation in the north component in the position. In cm.
31-40	East Horizontal Standard Deviation	9999999.99	0.00..9999999.99	Horizontal accuracy/standard deviation in the east component. In cm.
41-50	Horizontal Correlation Coefficient	A.99999999 Where A is the sign '-', or blank (meaning '+') and the remaining .99999999 is the numeric value.	The numeric value ranges from .00000000 .. .99999999	The correlation coefficient between the horizontal accuracy/standard deviation in north and the horizontal accuracy/standard deviation in east. Unitless
51-60	Ellipsoid Height Standard Deviation	9999999.99	0.00..9999999.99	In cm
61-64	BLANK	AAAA	"✦"	Spacer.
65	Accuracy Scaled Code	A	Y or N	Y – standard deviations scaled by multiplying them by the *a posteriori* standard deviation of unit weight N – standard deviations not scaled
66-80	Comment	A(15)	ASCII	Spacer or other use

Local Accuracy Record (*92*)

The local accuracy record is computed by the adjustment software and is inserted into the bluebook output file. The local accuracy is a value that represents the relative positional uncertainty between a pair of control points connected by observations. The north, east, and ellipsoid height standard deviations for this record are stored in cm at approximately 68.3% confidence (“one sigma”).

Columns	*Field Name*	*Field Format*	*Field Range*	*Field Description/Comments*
01-06	Sequence Number	999999	000001-999999	Optional.
07-10	Data Code	A99A	*92*	Record identifier.
11-14	Stand Point SSN (Station Serial Number)	9999	0001..9999	A number which identifies the station from which observations were made. Unique within the project.
15-16	Blank	AA	“✦”	Spacer.
17-20	Fore Point SSN (Station Serial Number)	9999	0001..9999	A number which identifies the station being observed. Unique within the project.
21-22	BLANK	AA	“✦”	Spacer.
23-32	North Horizontal Standard Deviation	9999999.99	0000000.00.. 9999999.99	Horizontal accuracy/standard deviation in the north component in the position. In cm.
33-42	East Horizontal Standard Deviation	9999999.99	0000000.00.. 9999999.99	Horizontal accuracy/standard deviation in the east component. In cm.
43-52	Horizontal Correlation Coefficient	A.99999999 Where A is the sign ‘-‘, or blank (meaning ‘+’) and the remaining .99999999 is the numeric value.	The numeric value ranges from .00000000 .. .99999999	The correlation coefficient between the horizontal accuracy/standard deviation in north and the horizontal accuracy/standard deviation in east. Unitless
53-62	Ellipsoid Height Standard Deviation	9999999.99	0000000.00.. 9999999.99	In cm.
63-66	Blank	AAAA	“✦”	Spacer.
67	Accuracy Scaled Code	A	Y or N	Y – standard deviations scaled by multiplying them by the *a posteriori* standard deviation of unit weight N – standard deviations not scaled
68-80	Comment	A(13)	ASCII	Spacer or other use.

Variance Factor Record (*93*)

For GPS observations (vectors), it is well known that the horizontal component is approximately two to three times more accurate than the vertical (ellipsoid height) component. In order to properly weight the observations, the NGS software "ADJUST" allows re-scaling of weights by separate horizontal and vertical components. The resulting horizontal and vertical variance factors are computed in the free adjustment and stored in the NGSIDB for each project. In addition to correctly scaling the horizontal and vertical errors with respect to one another within a GPS project, these variance factors also ensure a uniform set of weights between projects. This reflects the relative accuracies of the disparate sources of survey data when multiple GPS projects are combined into a single adjustment (such as regional or national readjustments).

Columns	*Field Name*	*Field Format*	*Field Range*	*Field Description/Comments*
01-06	Sequence Number	999999	000001-999999	Optional.
07-10	Data Code	A99A	*93*	Record identifier.
11-18	Factor by which to multiply horizontal components Units of 0.000	9999.999	0001..9999	A number which uniquely identifies a horizontal component factor.
19-26	Factor by which to multiply vertical components Units of 0.000	9999.999	0001..9999	A number which uniquely identifies vertical component factor.
27-80	Comment	A(54)	ASCII	Spacer or other use.

DATA SET TERMINATION RECORD (*aa*)

This must be the last record of every data set submitted.

The job code used in this record must be identical to the job code in both the *aa* Data Set Identification Record--the first record in the HZTL OBS data set--and the companion description data set.

aa FORMAT

CC 01-06	SEQUENCE NUMBER. OPTIONAL. RIGHT JUSTIFIED.
CC 07-10	JOB CODE. MUST BE *aa*. THE SYMBOL "aa" DENOTES THE TWO-CHARACTER JOB CODE ASSIGNED BY THE SUBMITTING ORGANIZATION.
CC 11-80	BLANK

For a more detailed explanation of the contents of the record see Chapter 1, page 1-1, JOB CODE AND POINT NUMBERING and Chapter 2, pages 2-1 through 2-3, HZTL OBS DATA SET RECORDS.

Chapter 5

VERTICAL CONTROL (VERT) DATA

INTRODUCTION

For coding and processing, the data required for geodetic vertical control (VERT data) have been divided into two sets. These are (1) observational data of elevation differences between survey points (OBS data) and (2) descriptive data including original and recovery descriptions (DESC data). Detailed instructions and formats for the coding and keying of the OBS and DESC vertical control data sets are contained in Chapter 6 and Annex P, respectively. The two data sets of each vertical control job must be submitted at the same time.

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 consists of data for a maximum of 9999 survey points, as “survey point" is defined 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 co-located geodetic projects intended for inclusion in the National Geodetic Survey Data Base, such as two leveling projects in the same area done at different epochs or simultaneous leveling and GPS projects.

A two-character alphanumeric code must be assigned to each vertical control job. This job code occurs in the first record of each data set (see Chapter 6 and Annex P) along with the data set type, the name of the submitting agency, and the data set creation date. These elements uniquely identify and positively correlate the respective data sets.

The first character of the job code must be a letter; the second character may be either a letter or a number (1 through 9). The characters chosen may then be arbitrary, or they may instead be cryptically meaningful, such as suggesting the location or nature of a project or a succession of projects accomplished by an agency.

A *vertical control point* is defined in this publication as a survey point which is described and monumented (or otherwise permanently marked) and 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 described temporary bench mark (TBM), a non-described TBM (occurring primarily in older data), or a permanent bench mark (monumented and described).

Each survey point in a vertical control job must be assigned a unique four-digit serial number (not necessarily consecutive) 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 station serial numbers (SSNs). This numbering system provides a unique identifier for every survey point in a vertical control job. The same SSN must be used consistently to refer to the same point in the OBS and DESC data sets of a vertical control job.

Descriptive data should be submitted for all survey points, including temporary bench marks (TBMs). The text “No description available” is acceptable for TBMs as long as other elements of the description such as the position, state and county have been entered.

MEDIA FOR SUBMITTING DATA

In principle, any computer-industry standard data-recording medium can be handled. The two media presently acceptable to NGS on a routine basis are compact disk (CD) and floppy disk. Changes with technology are expected.

The following information must be given for each data set:

1. Name and address of the submitting agency.

2. Project title and intended accuracy.

3. Name and telephone number of person to be contacted in case of difficulty with the data.

A letter of transmittal, in which the data are described and itemized and which provides the above information, must be prepared for each data shipment. One copy is to be enclosed with the shipment, one sent by separate mail to NGS, and a third retained by the sender. See ANNEX K for 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 inclusion in the National Geodetic Survey Data Base must be coded and keyed in conformity with the formats and specifications contained in this publication. In addition, <u>the keying of all data must be verified</u>. Detailed formats and specifications for the submission of vertical control jobs are contained in Chapter 6 (VERT OBS data) and Annex P (D-FILE data). The structure of an 80-character record is used for VERT OBS data.

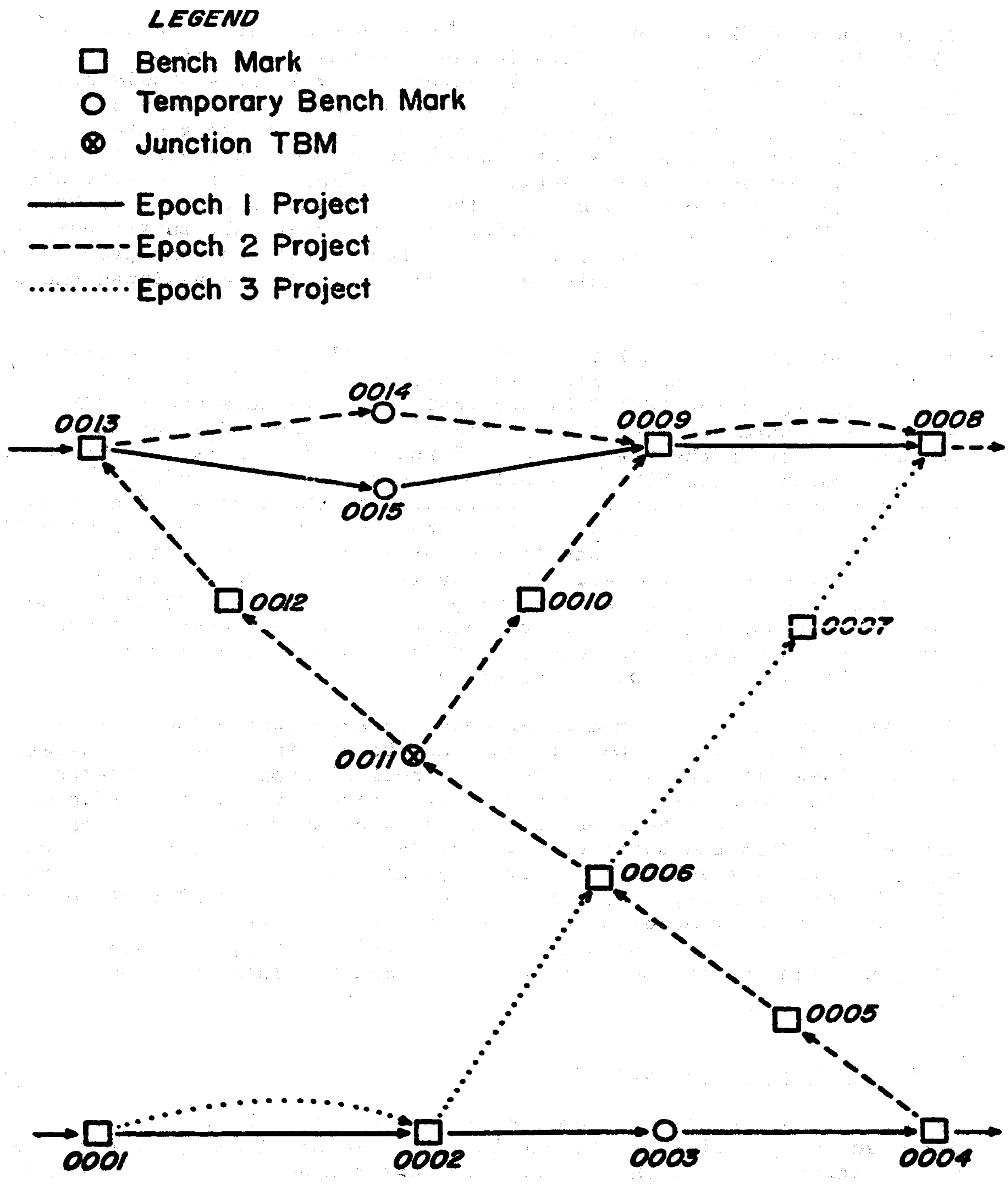


FIGURE 5-1 - Example of vertical survey point numbering.

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

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

SPECIAL CHARACTERS

In addition to upper-case alphabetic characters (letters A through Z) and numeric characters (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 nominally reserved for a record sequence number. This number remains useful, but it has become optional; the respective columns may be blank.

The historical purpose of numbering the records was to ensure that the proper sequence of the cards representing individual records in a data set could be verified and, if necessary, restored. The record sequence numbers were intended to be continuous throughout each data set, starting with the first record (the *aa* Data Set Identification Record) and ending with the last record (the *aa* Data Set Termination Record).

The sequence numbers, if used, should begin with 000010 on the first record of the data set 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.

Discounting any after-the-fact inclusions, the sequential numbering system described above will permit a maximum of 99,999 uniquely numbered records in any one data set. Should there be a need for a greater number of records in a data set, start over with 000010, 000020, ... etc.

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 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 discussed 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 description data set is treated in Annex P.

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 "card columns" (cc). 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 each 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 into 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 diagram illustrating the respective format has been prepared to serve as a model for that record - see format pages, p. 6-27 ff.

Except for the first and last records of the data set, the second character field of each record (cc 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 below). The first and last records of the data set (the *aa* Data Set Identification Record and the *aa* 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 (cc 1-6) is optional but is reserved for the respective record sequence number - see Chapter 5. The remaining portion of each record (cc 11-80) contains character fields which are peculiar to each individual record type.

TABLE 6-1
VERTICAL OBSERVATION DATA SET RECORDS

<u>FIRST RECORD</u>
aa - Data Set Identification Record

<u>LINE IDENTIFICATION DATA</u>
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)

<u>SURVEY EQUIPMENT DATA</u>
20 - Instrument Information Record
21 - Rod Information Record
22 - Rod Standardization Record
23 - Rod Calibration Record

<u>FIELD ABSTRACT DATA</u>
30 - Field Abstract Record

<u>OBSERVATION DATA</u>
40 - Survey Equipment Record
41 - Running Record
42 - River/Valley Crossing Record
43- Correction/Rejection Record

<u>LAST RECORD</u>
aa- Data Set Termination Record

<u>Note</u>: 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 *aa* Data Set Identification Record which contains the required information to identify the data set and to correlate it with its companion description 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 *aa* 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 (cc 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 (BMs and TBMs)) in the job does not exceed 9,999 (see Chapter 5). When two or more leveling lines are included in a vertical control job, the data for 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 below). Each line’s data must begin with a *10* record followed by the appropriate respective number of the other types of records in sequence and conclude with one or more *40 - series records.

TABLE 6-2
STRUCTURE OF THE VERT OBS DATA SET

aa Data Set Identification Record	
10-series record	
20-series records (if any)	FIRST
30 records	LEVELING LINE
40-series records	
10-series records	
20-series records (if any)	SECOND
30 records	LINE
40-series records	
::::	::::
::::	::::
10-series records	
20-series records (if any)	LAST
30 records	LINE
40-series records	
aa Data Set Termination Record	

A leveling line is a unit of field work consisting of a number of survey points (BMs and TBMs - 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. <u>Line Identification Data (*10*-Series) Records</u> (p. 6-7 ff.):

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

2. <u>Survey Equipment Data (*20*-Series) Records</u>: (p. 6-11 ff.):

   20 records (at least one if instrument not previously reported; in general, one for each previously unreported stadia factor determination) <u>for the first instrument used</u>
   20 records (at least one if instrument not previously reported; in general, one for each previously unreported stadia factor determination) <u>for the second instrument used</u>
   ::::
   20 records (at least one if instrument not previously reported; in general, one for each previously unreported stadia factor determination) <u>for the last instrument used</u>
   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) - <u>for the first rod used</u>
   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) - <u>for the second rod used</u>
   ::::

::::
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 last rod used

Note that for instruments and/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, p. 6-11.

3. Field Abstract Data (*30*) Records (p. 6-16 ff.):

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

4. Observation Data (*40*-Series) Records (p. 6-20 ff.):

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 date, 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 diagrams illustrating the respective formats will be found under FORMAT DIAGRAMS, p. 6-25 ff.

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 are for the most part self-explanatory; however, the following data items will be explained in greater detail:

Leveling Line: As stated on p. 6-4, a leveling line is a unit of field work consisting of a number of survey points (BMs and TBMs) 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 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; 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 characterize 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 purpose 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 in 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 "Classification, Standard 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 (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

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, p. 6-25 ff.), 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 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 *aa* 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).

(Note: The “century” columns are omitted on the *20*- and *40*-series records, and dates there are coded as six-digit integer numbers 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

<u>Time</u>: The time of day is coded as a four-digit integer number consisting of 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 <u>local zone time</u> 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).

<u>Time Zone</u>: 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

STANDARD TIME		DAYLIGHT TIME		TIME MERIDIAN	TIME ZONE DESCRIP'N	U.S. NAVY DESIGNATION
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 diagrams illustrating the respective formats are given in the format pages, p. 6-27 ff. 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, p. 6-3 ff., 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 (see p. 6-14). 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* 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 purpose 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; however, in this case, 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 are required to accommodate all calibration intervals (three per *23* record - see format pages, p. 6-27 ff.). 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 Database: 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 a 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 ensure that any omitted *20* Instrument Information Records have previously been made available for inclusion in the NGS Leveling Instrument and Rod database.

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 ensure that any omitted *21*, *22*, and/or *23* records have previously been made available for inclusion in the NGS Leveling Instrument and Rod database.

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.; special characters such as a blank (space), hyphen (minus sign), front slash (diagonal), 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. (See Data Field Types, p. 6-25 ff.)

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 Database, to keep these entries up-to-date, and to access this database for the retrieval of the respective stadia factor and/or rod calibration data in the course of routine processing of VERT OBS data sets. Use the identical serial number representation consistently whenever reference is made to that specific instrument or rod in any VERT OBS data set. Embedded blanks and leading zeros should be excluded from the serial number.

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 (p. 6-14) 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 (p. 6-23). 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 = 0.05 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 (possible materials 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	TEMPERATURE SCALE 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 lengths (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 station serial number (SSN). 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 diagram illustrating the respective format can be found on page 6-35.

Submit a *30* record for the first (starting) survey point, 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 BM or TBM via the loop.

Order of the *30* Records: 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 BMs and TBMs along the leveling line.

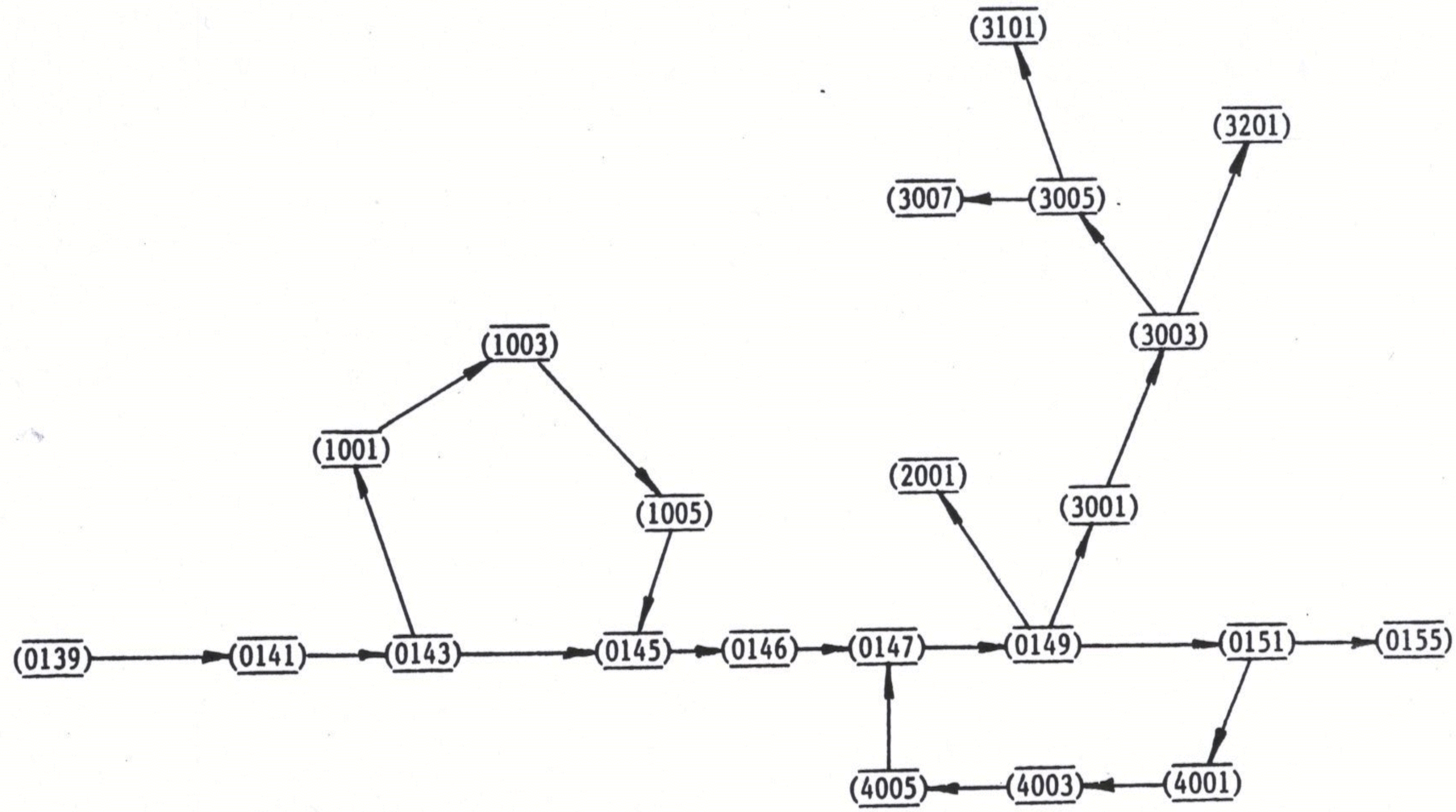
Normally, the *30* records should follow the same sequence as the respective survey points occur along the leveling line. However, one or more spurs may emanate from any survey point - in which case, after the *30* record for such a “base” point, the *30* records for all survey points along the longest spur must follow first, then those along the next longest spur, etc. Only when all spurs emanating from that base 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 examples in Figure 6-1, p. 6-18.

Station 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 p. 6-20 ff., OBSERVATION DATA RECORDS), each survey point in a vertical control job is assigned a job-specific serial number in the range 0001 to 9999. See Chapter 5 for an explanation of the survey point numbering system.

The station serial number (SSN) is also used in the correlation of the data pertaining to the BMs and TBMs which appear in the VERT OBS data set with the corresponding data contained in the companion description data set of the vertical control job. For this reason, special care must be taken to ensure that the identical station serial number assigned to a BM or TBM in the VERT OBS data set is also used to identify the same survey point in the respective companion description data set.

Designation: A vertical control point or BM is normally identified by a numeric or alphanumeric symbol which is stamped on the disk marker (or otherwise inscribed on the BM monument). Less frequently, a BM is assigned a recognizable name (e.g., when a horizontal control point also becomes a BM). Do not append the abbreviation or acronym of the agency whose name is precast in the marker or monument––see Annex D, Guideline 3.

A maximum length of 25 characters (including all imbedded blanks) is allowed for the designation on the *30* record. By contrast, a length of 50 characters is allowed in the description file, per Annex P. The designation from the description is used for publication. Use the same general guidelines for the designations of any TBMs.



<u>Sequence of the *30* Records:</u>

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

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

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, p. 6-17). Recall (p. 6-7) 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 and the stadia factor of the leveling instrument used (see Stadia etc. on p. 6-23 and Stadia Factor on p. 6-14). For this purpose, use the minimum section length if more than one running has been made over a section, as is the normal case.

With hand-keyed data, the accumulated distance (as well as the field elevation, p. 6-20) is carried on the *30* record to provide a check against certain undetected keying errors, line order errors, errors in the assignment of station 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. The accumulated distance must not be generated (e.g., by software) from the respective *41* and *42* 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, p. 6-17).

The end product of every running over a section of the leveling line is the respective observed, uncorrected elevation difference (see Elevation Difference, p. 6-24). 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.

With hand-keyed data, the field elevation (as well as the accumulated distance, p. 6-19) is carried on the *30* record to provide a check against certain undetected keying errors, line order errors, errors in the assignment of station 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. The field elevation must not be generated (e.g., by software) from the respective *41* and *42* records, as this would defeat the purpose for which it is intended.

<u>OBSERVATION DATA RECORDS</u>

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 diagrams illustrating the respective formats are on p. 6-27 ff. 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 (p. 6-7) that a leveling line is a unit of field work consisting of a number of survey points (BMs and TBMs) connected by differential leveling observations; a “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, as follows.

<u>Running</u>: 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* record(s) - 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 p. 6-22), as specified in the respective leading *40* record. See also STRUCTURE OF THE VERT OBS DATA SET, p. 6-3 ff.

Crossing: 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, p. 6-3 ff).

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. Also, if a running or a 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 formerly by the National Bureau of Standards and now by various entities.

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. This latter component 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 instrument.

The level collimation error must be determined at sufficiently frequent intervals–-daily, unless doing 3rd order work and/or using a level with reversible compensator--to permit the application of meaningful corrections to the respective leveling rod readings. 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. The effect of the collimation error cancels for a setup with backsight and foresight of equal length.

Tangent of Collimation Error: The observing procedure by means of which the collimation error is determined (commonly known as the “C-Test” or “peg 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 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 which denotes 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 which denotes 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 mentioned, 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, p. 6-16 ff. 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, used 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, p. 6-2), a 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.

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. Information and instructions concerning the data item to be entered in each data field are provided on the format pages.

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 and which refer back to the types enumerated in the following section.

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 entirely 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 coded*, 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.

If 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 an implied decimal point must be positioned in the floating-point field so that its integer part falls into the m rightmost “f” columns and its decimal fraction part into the n leftmost “d” columns, 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 or 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).

Data items are required unless noted as optional on the following format pages. Fields must be filled in accordance with the instructions given on the respective format page or in the text of this chapter.

Records or portions of records which are optional, or which may be omitted under certain circumstances, are so designated in the headings, footnotes, or bodies of the corresponding format pages.

aa DATA SET IDENTIFICATION RECORD

This must be the first record of every data set submitted.

The job code used in this record must be identical to the job code in the *aa* Data Set Termination Record--the last record in the Vertical Observation Data Set (VERT OBS)--and identical to the job code used in both the Data Set Identification Record and the respective companion description data set.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

aa FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Must be “000010" on this record. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Job code. Must be *aa*, where "aa" denotes the two-character code assigned by the submitting organization. The first “a” must be a letter; the second may be a letter or number.
CC 11-14	Data class. Must be “VERT.”
CC 15-18	Data type. Must be “OBS.”
CC 19-24	Abbreviation of submitting organization. See Annex C. If not listed there, request a new listing per hyperlink under “Annex C” at bluebook web site.
CC 25-66	Full name of submitting organization. See Annex C. Optional.
CC 67-68	Starting height datum code.“29" for NGVD 29, “88" for NAVD 88, “LT” for local tidal or “PR” for PRVD 02. Optional.
CC 69-72	Blank
CC 73-80	Date data set created. Integer. Century, year, month, day (ccyymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.

For a more detailed explanation of the contents of this record see Chapter 5, page 5-1, JOB CODE AND SURVEY POINT NUMBERING and Chapter 6, pp. 6-2 ff.

Column numbers and example data, *aa* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
000010*CX*VERTOBS NGS   NATIONAL GEODETIC SURVEY                  88    19990510
iiiiiisaasssssssssaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaabbbbiiiiiiii
```

10 LINE INFORMATION RECORD

This must be the leading record of each leveling line included in the job as noted on p. 6-3.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer and specific character) with the details of justification, decimal point placement, etc.

10 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *10*.
CC 11-18	Accession number (commonly called “L number”) such as “L22024"
CC 19-22	Line or part number if needed to supplement the accession number.
CC 23	Releveling code. “R” if releveling over previously established line, otherwise blank.
CC 24-31	Date field operations commenced. Integer. Century, year, month, day (ccyymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
CC 32-39	Date field operations terminated. Integer. Century, year, month, day (ccyymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
CC 40-41	Units of tolerance factor used to compute maximum disagreement allowed for each double-run section of the line. Either “MM” = mm/sq rt of km distance or “FT” = ft/sq rt of statute mile distance.
CC 42-45	Tolerance factor. Constant.
CC 46-47	Order and class of survey. Integer, per table below.
CC 48-49	State or country code for the state or country in which the leveling line begins and into which it extends–-see Annex A.
CC 50-51	State or country code for an additional state or country into which the leveling line extends–-see Annex A.
CC 52-53	State or country code for an additional state or country into which the leveling line extends–-see Annex A.
CC 54-56	Initials of Chief of Party (person responsible for the survey). Leave blank if unknown. Optional.
CC 57-76	Abbreviation of agency which made the observations. See Annex C.
CC 77	Blank
CC 78	Running code. Integer. ‘1' to indicate either single- or double-simultaneous run, ‘2' to indicate double-run.
CC 79	Rejection method. “A” if 1948 rejection algorithm used in reduction, “B” if Halperin rejection algorithm used in reduction. Optional.
CC 80	Position code. “1" to indicate positions obtained from *30* records. Optional.

10 LINE INFORMATION RECORD, cont.

ORDER AND CLASS OF SURVEY

ORDER	1ST			2ND			3RD	LOWER
CLASS	*	I	II	*	I	II	**	**
CODE	10	11	12	20	21	22	30	40

* Class unspecified　　**No class subdivision

Column numbers and example data, *10* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*10*L22024  2   R1999111020000224MM3.0 11CA    CS NGS                  1
iiiiiisiisaaaaaaaaaaaaaaiiiiiiiiiiiiiiiaacccciiaaaaaaaaaaaaaaaaaaaaaaaaaaaaaabiaa
```

<u>*11* LINE TITLE CONTINUATION RECORD</u> (Optional)
<u>*12*,*13*, *14* LINE TITLE CONTINUATION RECORDS</u> (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*, and *14* records for continuation and/or subtitles, if any.

Unless otherwise noted, data fields are required and are of type <u>a</u>lpha (left-justified). See <u>Data Field Types</u> on p. 6-25 ff. for requirements of the six data types (<u>a</u>lpha, <u>b</u>lank, <u>c</u>onstant, <u>f</u>loating-point, <u>i</u>nteger and <u>s</u>pecific character) with the details of justification, decimal point placement, etc.

11,*12*,*13*,*14* FORMAT

Card col.	
CC 01-06	<u>Sequence number</u>. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	<u>Data code</u>. Must be *11*,*12*,*13* or *14*.
CC 11-80	<u>Line title</u>. Abbreviate and/or edit a line title in the interest of fitting the entire title on the *11* record if possible. Use *12*-*14* records 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* 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.

<u>Column numbers and example data, *11*-*14* RECORDS</u>

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*11*TULARE-VASCO ARVIN-MARICOPA AREA CA
nnnnnn*12*9.1 KM SE OF KETTLEMAN CITY TO PIXLEY
iiiiiisiisaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
```

15 COMMENT RECORD (Optional)

Use the *15* record for any comment(s) pertinent to the leveling line. If the comment(s) exceed 70 characters, use another *15* record for continuation; any number *15* records is allowed. Do not divide words between consecutive *15* records.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

15 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *15*.
CC 11-80	Comment(s).

Column numbers and example data, *15* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*15*GRAVITY SURVEY OBSERVED OVER THIS LINE.
iiiiiisiisaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
```

20 INSTRUMENT INFORMATION RECORD

Submit this record for every instrument (identified by the respective Survey Equipment Code and Instrument Serial Number; see p. 6-13) once for each past stadia factor determination (to form a historical file) and when a new stadia factor is determined.

Omit this record for those instruments for which *20* records(s) containing identical information have been given in another line of this data set–or in a previously submitted VERT OBS data set.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

20 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *20*.
CC 11-13	NGS Survey Equipment Code. Integer. See Annex F.
CC 14-21	Instrument serial number, identical to the s/n given in the corresponding *40* record.
CC 22-37	Instrument manufacturer.
CC 38-49	Instrument model or type.
CC 50-69	Agency or firm which owns or has the custody of the instrument using the code in Annex C assigned to the agency.
CC 70-77	Determination date of stadia factor. Integer. Century, year, month, day (yymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
CC 78-80	Stadia factor. Integer. Instrument-specific number which when multiplied by stadia intercept gives distance to rod.

Column numbers and example data, *20* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*20*23190760   ZEISS/OBERKOCHENNI1         NGS                 19990217100
iiiiiisiisiiiaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaiiiiiiiiiii
```

21 ROD INFORMATION RECORD

Submit this record for every rod (identified by the respective Survey Equipment Code and Rod Serial Number; see p. 6-13) once initially with or without one or more *22* Rod Standardization and/or *23* Rod Calibration Records for that rod.

Aside from being required at least once initially for every rod, this record must precede every *22* and/or *23*,....,*22* and/or *23* record group subsequently submitted for any given rod.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

21 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *21*.
CC 11-13	NGS Survey Equipment Code. Integer. See Annex F.
CC 14-21	Rod serial number.
CC 22-37	Rod manufacturer. Optional.
CC 38-49	Rod model or type (for example, “INVAR” or “LOVAR”). Optional.
CC 50-69	Agency or firm which owns or has custody of the rod, using the code in Annex C assigned to the agency. Optional.
CC 70-71	Rod units. CF (centifoot, 0.01 ft), CM (centimeter, 0.01 m), CY (centiyard, 0.01 yd) or HC (half-centimeter, 0.005 m)
CC 72	Graduation code. Integer. 1 = line graduation, single scale. 2 = line graduation, double scale. 3 = block graduation including checkerboard. 4 = other.
CC 73-80	Blank

Column numbers and example data, *21* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*21*316120900  KERN            INVAR       NGS                 HC2
iiiiiisiisiiiaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaibbbbbbbb
```

22 ROD STANDARDIZATION RECORD

Submit this record for every rod (with or without accompanying *23* record(s)) once for each past standardization or calibration (to form a historical file) and whenever rod is restandardized or recalibrated--see footnote. The *22* record is optional if all data elements contained in the record are inferable from accompanying *23* records. Not required for 3rd- and lower-order work.

Omit this record for those rods for which *22* and/or *23* records(s) containing identical data have been given in another line of this data set or in a previously submitted VERT OBS data set.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

22 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *22*.
CC 11-13	NGS Survey Equipment Code. Integer. See Annex F.
CC 14-21	Rod serial number.
CC 22-27	Abbreviation of laboratory or other source of standardization. Enter “MAKER” if standardization is furnished by the rod manufacturer.
CC 28-33	Date of standardization. Integer. Year, month, day (yymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
CC 34	Temperature scale of standardization. “C” = Celsius; “F” = Fahrenheit.
CC 35-38	Standardization temperature. Constant.
CC 39-44	Coefficient of Expansion x 10,000. Constant. See p. 6-15.
CC 45	A-flag. “A” = assumed; blank otherwise. See p. 6-16.
CC 46-51	Rod Excess x 1,000. Constant. See p. 6-16. Optional if inferrable from *23* record(s).
CC 52	Blank.
CC 53-58	Index error in rod units. Constant. See p. 6-16. Optional if inferrable from *23* record(s).
CC 59	Blank.
CC 60-65	Computed Rod Scale Constant in rod units. Used with detailed rod calibration data only. Constant.
CC 66	Blank.
CC 67-70	3-sigma error of micrometer. Used with detailed rod calibration data only. Units of microns, to 1 decimal place. Floating point with implied decimal after cc 69.
CC 71-79	Blank.
CC 80	Century code for date of standardization. “8" for 19th century, “9" for 20th, “0" for 21st century.

Column numbers and example data, *22* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*22*316120900  NBS   990211C25.0.0080 A-0.650 .01534
iiiiiisiisiiiaaaaaaaaaaaaaaiiiiiiacccccccccacccccbccccccbccccccbfffdbbbbbbbbba
```

23 ROD CALIBRATION RECORD

In addition to the respective *22* record, submit one or more *23* records for every past single- and multiple-temperature calibration of the rod for which the data are available and when rod is recalibrated. Not required for 3rd- and lower-order work.

Omit this record for those rods for which *22* and/or *23* records(s) containing identical data have been given in another line of this data set or in a previously submitted VERT OBS data set.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

23 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *23*.
CC 11-13	NGS Survey Equipment Code. Integer. See Annex F.
CC 14-21	Rod serial number.
CC 22-27	Abbreviation of laboratory or other source of calibration. Enter “MAKER” if calibration is furnished by the rod manufacturer.
CC 28-33	Date of calibration. Integer. Year, month, day (yymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
CC 34	Temperature scale of calibration. “C” = Celsius; “F” = Fahrenheit.
CC 35-38	Calibration temperature. Constant with explicit decimal pt.
CC 39-40	Units of Measured Length (FT, MT or YD). For the three below intervals 1, 2 and 3, specify the point on the rod (xxx in rod units) at which the calibration measurement starts, the point at which it ends, and the measured length of the respective interval in feet, meters or yards per discussion of Units on p. 6-24.
CC 41-43	Starting point, Interval 1. Integer. In rod units.
CC 44-46	Ending point, Interval 1. Integer. In rod units.
CC 47-53	Measured Length, Interval 1. Floating-point. Decimal point implied after CC 47.
CC 54-56	Starting point, Interval 2. Integer. In rod units.
CC 57-59	Ending point, Interval 2. Integer. In rod units.
CC 60-66	Measured Length, Interval 2. Floating-point. Decimal point implied after CC 60.
CC 67-69	Starting point, Interval 3. Integer. In rod units.
CC 70-72	Ending point, Interval 3. Integer. In rod units.
CC 73-79	Measured Length, Interval 3. Floating-point. Decimal point implied after CC 73.
CC 80	Century code. “8" for 19th century, “9" for 20th, “0" for 21st century. Optional.

Column numbers and example data, *23* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*23*316120900  NBS   990211C25.0MT000200100005000040020000700006003000090
iiiiisiisiiiaaaaaaaaaaaaaaiiiiiiaccccaaiiiiiifddddddiiiiiifddddddiiiiiifdddddda
```

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 p. 6-16 ff.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

30 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *30*.
CC 11-14	Station serial number (SSN). Integer.
CC 15-39	Designation. 25 characters or less, abbreviated and/or edited to be this length per Annex D. A length of 30 characters is allowed in the HZTL OBS data set (see Chapter 2, p. 2-31), and 50 characters in the GEOD DESC data set (see Annex P, section 3.3.1, Description Header Record, Field Format of Designation). The 50-character station name will be used in the automated publication of geodetic data sheets, station descriptions, and associated indexes. Three versions of a long station name may then exist - one 25 characters long for processing vertical observations, one 30 characters long for processing horizontal observations, and one 50 characters long used for publication. The three versions should differ only as to the manner in which the station name has been abbreviated and/or edited.

Items in CC 40-61 must be keyed from the Field Abstract and not generated from the respective *41*/*42* records. See pp. 6-19 and -20.

CC 40-41	Units of distance, per footnote.
CC 42-49	Accumulated Distance. Constant with explicit decimal point.
CC 50-51	Units of Elevation. “MT”, “FT” or “YD”.
CC 52-61	Field Elevation. Constant with explicit decimal point.
CC 62-67	Permanent identifier (PID) if assigned. From NGS data base. Optional.
CC 68-73	North latitude to nearest second. Integer. Optional.
CC 74-80	West longitude to nearest second. Integer. Optional.

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

Column numbers and example data, *30* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*30*0187D 1056                         KM23.49   MT57.11702  FU30763556041194019
iiiiiisiisiiiiaaaaaaaaaaaaaaaaaaaaaaaaaaaaccccccccaaccccccccccaaaaaaiiiiiiiiiiiii
```

40 SURVEY EQUIPMENT RECORD

The leading record of every *40*, *41*, *41*,...*41* set containing runnings made on the same date using the same equipment and affected by the same collimation error.

Submit this record to reflect the start of each day’s work; also to reflect a change in any of the following: an item of survey equipment, the height of instrument by 5 cm or more, the heights of the temperature probes, or the determination of collimation error. Follow a *40* record by one or more *41* records for the runnings to which data on the *40* record apply.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

40 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *40*.
CC 11-16	Date of running. Integer. Year, month, day (yymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
CC 17-19	NGS survey equipment code for level instrument–see Annex F. Integer.
CC 20-27	Instrument serial number, identical to the s/n given on the corresponding *20* record.
CC 28	M-Flag. “M” if micrometer is used, blank otherwise.
CC 29-31	NGS survey equipment code for Rod 1–see Annex F. Integer.
CC 32-39	Rod 1 serial number, identical to the s/n given on the corresponding *21* record.
CC 40-42	NGS survey equipment code for Rod 2–see Annex F. Integer.
CC 43-50	Rod 2 serial number, identical to the s/n given on the corresponding *21* record.
CC 51-53	Average height of instrument in cm. Integer.
CC 54-56	Height of upper temperature probe in cm. Integer. This and next two fields blank if temperature probes were not used.
CC 57-59	Height of lower temperature probe in cm. Integer.
CC 60-62	Height of middle temperature probe in cm. Integer.
CC 63-64	Blank.
CC 65-69	Tangent of collimation error x 1000 (i.e., enter with decimal point moved three places to the right.) Constant. Leave blank if none determined. See pp. 6-22 and 6-23.
CC 70	Time zone of collimation error determination. See Annex H. Optional in a *40* record preceding a *42* record.
CC 71-74	Local time of collimation error determination–hours and minutes (HHMM). Optional in a *40* record preceding a *42* record.
CC 75-80	Blank.

Column numbers and example data, *40* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*40*99032623190760   M316118018  316120900  150250050250  -.005T0750
iiiiisiisiiiiiiiiiaaaaaaaaaiiiaaaaaaaaiiiaaaaaaaaiiiiiiiiiiiibbcccccaiiiibbbbbb
```

41 RUNNING RECORD

Submit this record for every running other than a river/valley crossing. The *41* records for all runnings made on the same date, using the same equipment, and to which the same collimation error applies must be grouped immediately after the respective *40* record.

Unless otherwise noted, data fields are required and are of type <u>a</u>lpha (left-justified). See <u>Data Field Types</u> on p. 6-25 ff. for requirements of the six data types (<u>a</u>lpha, <u>b</u>lank, <u>c</u>onstant, <u>f</u>loating-point, <u>i</u>nteger, and <u>s</u>pecific character) with the details of justification, decimal point placement, etc.

41 FORMAT

Card col.	
CC 01-06	<u>Sequence number</u>. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	<u>Data code</u>. Must be *41*.
CC 11-16	<u>Date of running</u>. Integer. Year, month, day (yymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
CC 17-20	<u>Starting station serial number</u> (SSN). Integer. Must be same as SSN on the corresponding *30* record.
CC 21-24	<u>Ending station serial number</u> (SSN). Integer. Must be same as SSN on the corresponding *30* record.
CC 25	<u>Time zone</u>–see Annex H.
CC 26-29	<u>Local starting time of running</u>–hours and minutes (HHMM). Integer.
CC 30-33	<u>Local ending time of running</u>–hours and minutes (HHMM). Integer.
CC 34	<u>Temperature scale</u>: “C” = Celsius, “F” = Fahrenheit.
CC 35-38	<u>Air temperature</u> at starting time and place. Constant.
CC 39-42	<u>Air temperature</u> at ending time and place. Constant.
CC 43	<u>Wind code</u>. Integer. See p. 6-22.
CC 44	<u>Sun code</u>. Integer. See p. 6-23.
CC 45-47	<u>Number of setups</u> in the running. Integer.
CC 48	<u>Stadia intercept code</u>. “F” = full, “H” = half.
CC 49-53	<u>Sum of backsight stadia intercepts</u>. Floating-point with implied decimal point after CC 52. Enter to the nearest 0.1 of the respective rod unit.
CC 54-58	<u>Sum of foresight stadia intercepts</u>. Floating-point with implied decimal point after CC 57. Enter to the nearest 0.1 of the respective rod unit.
CC 59-60	<u>Units of length</u>–see *30* record.
CC 61-65	<u>Length of running</u> in the units indicated, if stadia data unavailable; leave blank otherwise. Constant.
CC 66-67	<u>Units of elevation difference</u>–“MT”, “FT”, or “YD”.
CC 68-77	<u>Elevation difference</u>. Constant. The observed, uncorrected elevation difference determined by the running.
CC 78-80	<u>Initials of the observer</u>. Optional.

<u>Column numbers and example data, *41* RECORD</u>

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*41*75032601870091T13171358C18.920  02 12H 1563 1572       MT-5.68392  NLM
iiiiiisiisiiiiiiiiiiiiiiaiiiiiiiiacccccccciiiiiaffffdffffdaacccccaaccccccccccaaa
```

42 RIVER/VALLEY CROSSING RECORD

Submit this record for each river/valley crossing along the leveling line.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

42 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *42*.
CC 11-16	Date of crossing. Integer. Year, month, day (yymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
CC 17-20	Starting station serial number (SSN). Integer. Must be same as SSN on the corresponding *30* record.
CC 21-24	Ending station serial number (SSN). Integer. Must be same as SSN on the corresponding *30* record.
CC 25	Time zone–see Annex H.
CC 26-29	Local starting time of crossing–hours and minutes (HHMM). Integer.
CC 30-33	Local ending time of crossing–hours and minutes (HHMM). Integer.
CC 34-58	Blank.
CC 59-60	Units of length–see *30* record.
CC 61-65	Total length of the river/valley crossing in the units indicated. Constant.
CC 66-67	Units of elevation difference–“MT”, “FT”, or “YD”.
CC 68-77	Elevation difference. Constant. The observed, uncorrected elevation difference determined by the crossing.
CC 78-80	Blank.

Column numbers and example data, *42* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*42*75101801130114R10251100                         KM0.75 MT0.61874
iiiiiisiisiiiiiiiiiiiiiiaiiiiiiiibbbbbbbbbbbbbbbbbbbbbbbbbaacccccaaccccccccccbbb
```

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 traceable to the National Institute of Standards and Technology, or 3) the running or river/valley crossing is to be rejected.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

43 FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Increment by 10 on successive records to allow for insertions. Optional.
CC 07-10	Data code. Must be *43*.
CC 11-16	Date of running or river/valley crossing. Integer. Year, month, day (yymmdd). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.
CC 17-20	Starting station serial number (SSN). Integer.
CC 21-24	Ending station serial number (SSN). Integer.
CC 25-28	Local starting time of crossing–hours and minutes (HHMM). Integer.
CC 29-35	Refraction Correction in mm. Constant with explicit decimal point.
CC 36	Field/office rejection. “F” = field rejection; “O” = office rejection. Blank = not rejected.
CC 37-43	Rod correction in mm. Constant with explicit decimal point.
CC 44	Temperature scale. “C” = Celsius; “F” = Fahrenheit.
CC 45-49	Mean temperature for upper probe. Constant with explicit decimal point.
CC 50-54	Mean temperature for lower probe. Constant with explicit decimal point.
CC 55-59	Mean temperature for middle probe. Constant with explicit decimal point.
CC 60	Temperature code. “O” = observed, “P” = predicted.
CC 61-71	Blank.
CC 72-80	Partial Refraction Correction. Constant with explicit decimal point in cc 77.

Column numbers and example data, *43* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*43*990914012201231452-1.21   -0.81  C19.1 20.1 19.4 P
iiiiisiisiiiiiiiiiiiiiiiiiicccccccacccccccaccccccccccccccccabbbbbbbbbbbccccccccc
```

aa DATA SET TERMINATION RECORD

This must be the last record of every data set submitted.

The job code used in this record must be identical to the job code in both the *aa* Data Set Identification Record--the first record in the VERT OBS data set--and the companion description data set.

Unless otherwise noted, data fields are required and are of type alpha (left-justified). See Data Field Types on p. 6-25 ff. for requirements of the six data types (alpha, blank, constant, floating-point, integer, and specific character) with the details of justification, decimal point placement, etc.

aa FORMAT

Card col.	
CC 01-06	Sequence number. Integer. Optional.
CC 07-10	Job code. Must be *aa*, where "aa" denotes the two-character code assigned by the submitting organization.
CC 11-80	Blank

Column numbers and example data,*aa* RECORD

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
nnnnnn*CX*
iiiiiisiisbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
```

Data Set Structure

```
*aa* Data Set Identification Record
______________________________
*10*-series records
*20*-series records, if any     FIRST
*30* records                    LINE
*40*-series records
______________________________

*10*-series records
*20*-series records, if any     SECOND
*30* records                    LINE
*40*-series records
______________________________

::::                            ::::
::::                            ::::

______________________________
*10*-series records
*20*-series records, if any     LAST
*30* records                    LINE
*40*-series records
______________________________

*aa* Data Set Termination Record
```

CHAPTER 9

GRAVITY CONTROL (GRAV) DATA

INTRODUCTION

For coding and processing purposes, the data associated with geodetic gravity control (GRAV data) have been divided into three groups. The three gravity control data groups are (1) the field observations of gravity data between survey points, i.e., counter dial readings (OBS data), (2) descriptive data including original and recovery descriptions (DESC data), and (3) adjusted gravity values (ADJU data). Detailed instructions and formats for the coding and keying of the OBS, DESC, and ADJU gravity control data sets are contained in Chapters 10, 7, and 11, respectively. The formats and specifications for the keying of GRAV DESC data are identical to those used for VERT DESC data.

Although all three data types are normally generated in connection with each gravity control survey project, OBS, DESC, and ADJU data must be submitted to the National Geodetic Survey as separate data sets. There are two modes in which gravity control data may be submitted to the National Geodetic Survey. In order of preference, they are:

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

MODE 2 - Adjusted Gravity Data (GRAV ADJU data)

The foregoing implies that every gravity control survey project (or several projects submitted as one "job" - see below) will be received at the National Geodetic Survey as one of two distinct data sets: either OBS and DESC data sets under mode 1, or ADJU data under mode 2. The data sets of each gravity control job must be submitted at the same time. There are distinct benefits to be realized when gravity control data intended for insertion in the gravity 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 examined and edited if necessary. This process insures that the values of the new survey points will be consistent with the existing gravity control in that area.

By contrast, mode 2 data consist of isolated points whose final adjusted gravity values are submitted. Because the connecting observations are not available, these adjusted values cannot be fully verified.

Mode 2 data are not entered into the National Geodetic Survey gravity data base. This type of data is entered into the NGS gravity working file. The format for ADJU data must conform with the specifications in Chapter 11.

The distinction between the gravity data base and the working file is thus made. The gravity data base contains values for control points whose accuracy and descriptions are verifiable by NGS. The working file contains values for survey points which are not fully verifiable by NGS and/or for which descriptions do not exist within the NGS.

JOB CODE AND SURVEY POINT NUMBERING

The basic unit or grouping of data to be submitted is given the name "job". A gravity control job may consist of data for a maximum of 9999 OBS data stations or an unlimited number of ADJU stations. A job may consist of a single survey (i.e., one unit of field work), or a number of surveys may be included in one job. It is suggested that geographic proximity be the determining factor in selecting gravity control surveys for inclusion in any one job. A gravity "control point" (base station) is defined as a survey point which is monumented (or otherwise permanently marked), described and whose (adjusted) gravity value is known. A gravity control point may be a National Geodetic Survey vertical control "bench mark" (BM) but usually is not. A "survey point", in turn, is defined as any point which has one or more gravity differences measured to it or from it. A survey point may or may not have an accompanying description.

A "loop" is the basic component of any gravity control survey. A loop consists of a sequence of gravity observations which begins on a gravity control point and ends on a gravity control point. There are three common types of loop sequences:

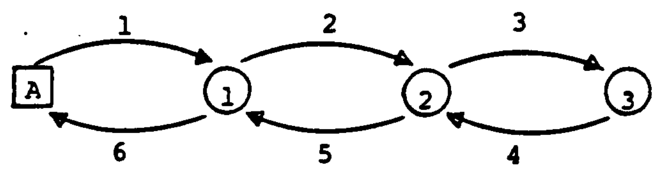
1. Ladder Sequence
2. Modified Ladder Sequence
3. Line Sequence

The ladder sequence loop begins and ends at the same control point. The survey points are observed twice during the loop. The return portion is run opposite to the forward run. This loop sequence is often used for scale factor determinations or high accuracy network densification.

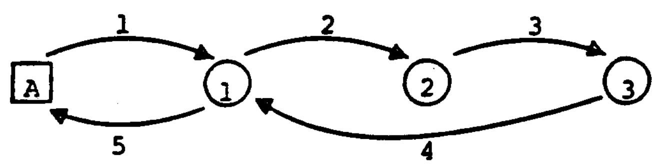
The modified ladder sequence loop also begins and ends at the same control point. However, not all the survey points are observed twice during the loop.

The line sequence loop begins at a control point and ends at a different control point. The survey points are often only observed once.

Figure 9-1 illustrates each of the loop sequences.

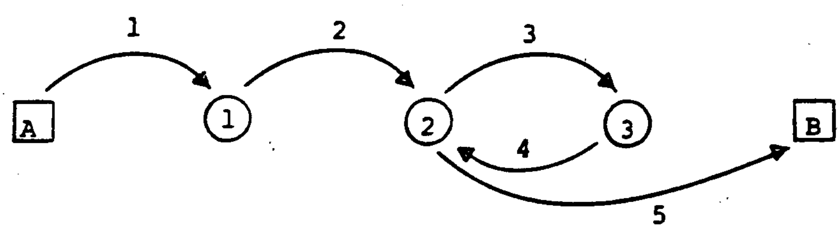


A. Ladder Sequence Loop (A-1-2-3-2-1-A for lines, A-B-C-B-A for Base Station Ties)



Reobserve at least 1 intermediate station.

B. Modified Ladder Sequence Loop (A-1-2-3-1-A)



C. Line Sequence Loop (A-1-2-3-2-B)

KEY:

 = Control point (base station where the gravity value is known or is tied directly to a known base station)

 = Survey points on which gravity values are to be established.

 = Observing sequence and direction.

Figure 9-1 Examples of Loop Sequences

A two-character alphanumeric code must be assigned to each gravity 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 a total of 910 uniquely identified job codes to be submitted by any one agency. Should this sequence be exhausted, start assigning job codes again from the beginning: A1, A2, etc.

Each survey point that is observed and each control point used in a gravity control job must be assigned an unique four-digit serial number (not necessarily consecutive) in the range 0001 through 9999. If known, the point must also be identified by its Archive Cross Reference Number (ACRN). If the number of survey points exceeds 9999, the gravity control data in question must be divided and submitted as two or more jobs. If possible, gravity surveys should not be subdivided. 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 ADJU data sets of a gravity control job. All control points for which recovery descriptions are written in this current survey, but which are not observed in this current survey, will be assigned the SPSN code 0000.

MEDIA FOR SUBMITTING DATA

At present, the only computer readable media acceptable to the National Geodetic Survey on a routine basis is standard 9-track magnetic tape. Magnetic tape is the preferred medium for both small and large volumes of data: agencies submitti large volumes of data should use this medium exclusively. Printed data may be accepted by NGS only for very small, isolated jobs on a case-by-case basis.

The following information must be given for each data set submitted as printed data:

1. Name and address of the submitting agency.

2. Description of the contents of the printed sheets by data type.

3. 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 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 submitting agency.

3. Number of files and a description of each file and data type.

4. Computer system on which the tape was created (e.g., IBM 360/XXX, CDC 6600, etc.).

5. Internal label information (non-labeled).

6. Number of tracks (9) and parity (even or odd).

7. Recording density (800, 1600, or 6250 BPI).

8. Record length (80) and block size.

9. Character representation code (ASCII).

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 mail to the National Geodetic Survey, 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 back-up of all data included in a shipment until the specific data have been sucessfully read by the National Geodetic Survey.

CODING, KEYING, AND DATA VERIFICATION

All data submitted to the National Geodetic Survey 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 gravity control jobs are contained in Chapter 10 (GRAV OBS data), Chapter 7 (VERT DESC data), and in Chapter 11 (GRAV ADJU data). The formats were designed to allow the keying and verification of the data to be accomplished on standard equipment. The 80-character record (card image format) has been adopted for all applications.

In keying the data entries, care must be taken to ensure 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" -- O - letter "O"

1 - number "one" -- l - letter "L"

2 - number "two" -- 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
( ) blank
(,) comma
(.) period or decimal point
($) dollar sign
(+) plus sign
(-) minus sign or hyphen
(=) equal sign
(/) slash or solidus
(() left parenthesis
()) right parenthesis

NOTE: A restriction on characters is imposed for the designations of survey points (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 by 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 number 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.

Chapter 10

GRAVITY OBSERVATION (GRAV OBS) DATA

INTRODUCTION

This chapter provides detailed specifications and instructions for the coding and keying of the observational data set of a gravity survey job. As explained in Chapter 9, a gravity survey job may consist of two distinct data sets which must be submitted together. The companion data set to the gravity observation (GRAV OBS) data set treated in this chapter is the data set containing original descriptions and recovery descriptions for the gravity stations that are in the gravity survey job. This description (GRAV DESC) data set is detailed in Chapter 7. The format for the GRAV DESC data set is identical to the VERT DESC format. However, it should be noted that the Data Set Identification Record accompanying the GRAV DESC data set should reflect the GRAV and not VERT data class.

The GRAV OBS format is a data transmittal format and not intended as a data acquisition format. NGS specific techniques and instructions for the acquisition of gravity field data can be found in the National Geodetic Survey Operations Manual, Chapter 2.6. These instructions apply only to NGS field parties although other agencies may elect to use them.

GRAV OBS DATA SET RECORDS

Data that constitute a GRAV OBS data set are organized into five categories:

1. Survey Identification Data
2. Survey Equipment Data
3. Observation Data
4. Loop Termination Data
5. Station Information Data

Within these categories, the respective data have been grouped into "records". A record is a string of characters containing data codes in a specific format. Every record in a GRAV OBS data set consists of 80 characters or "columns". Within each record, the 80 columns are divided into fixed-length 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 items are entered as strings 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 GRAV OBS survey job are listed in Table 10-1. Each type of record has been given a name, and a block diagram

TABLE 10-1
GRAVITY OBSERVATION DATA SET RECORDS

FIRST RECORD
AA - Data Set Identification Record

SURVEY IDENTIFICATION DATA
10 - Survey Information Record
11 - Survey Title Record
12 - Survey Title Continuation Record (Optional)
13 - Survey Title Continuation Record (Optional)
14 - Survey Title Continuation Record (Optional)
15 - Comment Record (Optional)

SURVEY EQUIPMENT DATA
20 - Instrument Information Record
21 - Instrument Calibration Header Record
22 - Instrument Calibration Information Record
23 - Instrument Scale Factor Header Record
24 - Instrument Scale Factor Record
25 - Comment Record (Optional)

OBSERVATION DATA
30 - Land Observation Record
32 - Marine Observation Record
35 - Comment Record (Optional)

LOOP TERMINATION DATA
40 - Loop Termination Record
45 - Comment Record (Optional)

STATION INFORMATION DATA
50 - Station Information Record
55 - Comment Record (Optional)

LAST RECORD
AA - Data Set Termination Record

Note: The symbol *AA* denotes the two-character job code assigned by the submitting agency - see Chapter 9.

illustrating the respective format has been prepared to serve as a model for that record - see FORMAT DIAGRAMS. An example OBS data set also appears in figure 10-1. 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*, ..., - see Table 10-1). The first and last records of the data set (the Data Set Identification Record and the Data

Set Termination Record) display in this field the two-character alphanumeric job code assigned by the submitting agency (*A1*, *A2*, ..., *ZZ* - see Chapter 9). The first character field of every record (columns 1-6) is reserved for the respective record sequence number - see Chapter 9. The remaining portion of each record (columns 11-80) contains character fields that are specific for each individual record type.

STRUCTURE OF THE GRAV OBS DATA SET

The first record of a GRAV 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 GRAV DESC data set - job code, data type (GRAV OBS), name of submitting agency, and the date the data set was created. The last record of the data set must be the Data Set Termination Record. It is the only 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 GRAV OBS data set records which are bracketed by these two delimiter records may pertain to one or more units of field work; i.e., field observation data for several gravity surveys may be submitted in one GRAV OBS data set under the same job code, provided that the total number of survey points in the job does not exceed 9,999 (see Chapter 9). Each loop must be terminated by a *40* record. A *10* record following a *50* series record (or a *40* series record for a marine gravity survey) signifies the beginning of a new gravity survey within this data set.

A gravity survey is a unit of field work consisting of a number of survey points which are connected by gravity observations. When coded as part of a GRAV OBS data set, a gravity survey is a block of records comprising record groups arranged in the following order:

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

    10 Record
    11 Record (*12*, *13*, and *14* records optional)
    15 Comment Records (optional, any number allowed)

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

    20 Instrument Information Records
    21 Instrument Calibration Header Records
    22 Instrument Calibration Information Records
    23 Instrument Scale Factor Header Records
    24 Instrument Scale Factor Records
    25 Comment Records (optional, any number allowed)

3. Observation Data (*30*-Series) Records:

    30 Land Observation Record giving all information relative to a specific land observation at a station within a loop of a survey
    32 Marine Observation Record giving information observed during a marine gravity survey
    35 Comment Records (optional, any number allowed)

4. Loop Termination Record:

   40 Records
   45 Comment Records (optional, any number allowed)

5. Station Information Record:

   50 Records giving station information related to a specific SPSN. This includes station position, elevation and designation.

   55 Comment Record (optional, any number allowed)

SURVEY IDENTIFICATION DATA RECORDS

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

The survey 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 survey identification data and is always required. The *11* record is optional; however, it is highly desirable that a survey title (reflecting the geographic location of the survey - see below) be given. The survey 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 included 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 be included as many *15* records as appropriate to give comments pertinent to the survey (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:

Order and Class of Survey: A two-digit code is provided on the *10* record to specify the intended 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 Standards and Specifications for Geodetic Control Networks, 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. In addition to the four gravity control survey categories defined in this publication, two other survey categories need to be considered - old gravity control surveys of first order for which no class is specified, and surveys of lower-than-third-order accuracy. The respective two-digit codes are as follows:

Two Digit Accuracy Codes

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

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

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 gravity survey 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.

Survey Title: The use of geographic location alone as the title of a gravity survey has traditionally been the practice of the NGS and its predecessors. In general, the title by which the gravity survey 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 abbreviate the title in the interest of fitting the entire title on the *11* Survey Title Record, if at all possible. However, up to three additional records (the *12*, *13*, and *14* Survey Title Continuation Records) may follow the *11* Survey 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 survey 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 survey 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 survey proper should follow as a subtitle on one or more of the continuation records. Example:

11 Record: NAVD REGION I- NEW ENGLAND
12 Record: BOSTON MA TO BANGOR ME

DATE AND TIME

The date of the GRAV 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* Survey Information Record. In addition, character fields are reserved for the date and/or time on several other records of the GRAV OBS data set. Throughout the GRAV OBS data set, date and time are to be coded as follows:

Date: The 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 data 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

However, the complete date and time are requested for every *30* series record where applicable.

Time: The time of day is coded as a four-digit integer number consisting of two-digit groups denoting (from left to right) the hours and minutes (HHMM) of a 24-hour clock except on the *32* record where it is coded as a six-digit integer consisting of hours, minutes and seconds. In every case, the Greenwich Mean time is to be used. In this manner, ambiguities are avoided concerning the date, which is always assumed to be the "Greenwich" time and date.

The worldwide use of the time zone descriptions and the U.S. Navy one-letter designations are illustrated in ANNEX H. This annex should be used to ascertain the correct conversions from "local" date and time to Greenwich date and time.

SURVEY EQUIPMENT DATA RECORDS

20 Instrument Information Record
21 Instrument Calibration Header Record
22 Instrument Calibration Information Record
23 Instrument Scale Factor Header Record
24 Instrument Scale Factor Record
25 Comment Record (optional)

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 gravity meters used to carry out the observations. See STRUCTURE OF THE GRAV OBS DATA SET for the proper sequence in which the *20*-series records must appear in the block of records which constitutes a survey in a GRAV OBS data set.

The *20* Instrument Information Record contains the data required to completely identify a gravity meter.

The *21* Instrument Calibration Header Record contains all of the information necessary to completely identify a calibration of a gravity meter. It is extremely important that a *21* record immediately precede the *22* records which it identifies.

The *22* Instrument Calibration Information Record contains the actual data used to calibrate the meter. This record contains a sequence of ordered pairs, counter reading/value in mgals. The first *22* record for a particular calibration must start with the lowest counter reading as the first entry and proceed sequentially until the entire calibration has been recorded. As many *22* records as are necessary to completely record a calibration may be used. In other words, there is no limit to how detailed or gross the calibration interval may be. The standard Table 1 interval (see fig. 10-2) for La Coste & Romberg G meters is 100 counter dial units. There is no requirements to maintain this interval or even to have the interval remain constant. It should be noted that, depending upon the instruments used as well as the intended order and class of survey, the *21* and *22* records may not be necessary.

The *23* Instrument Scale Factor Header Record contains all the information necessary to completely identify a scale factor determination and correlate that determination with a gravity meter. A *23* record must preceed a *24* record and identify the information given in the *24* record.

The *24* Instrument Scale Factor Record defines a scale factor for a gravity meter and is related to the preceeding *23* record.

The *25* Comment Record may be submitted anywhere within the *20* series records to denote changes from normal procedures or any information which might impact the quality of the data.

<u>NGS Gravity Instrument (Meter) File:</u> The purpose of the *20* series records is to provide input to a permanent computer file in which an historic record is maintained for each gravity meter ever used in a GRAV OBS data set submitted to the National Geodetic Survey. A record is established in this file, for an instrument, the first time it is encountered in the processing of a GRAV OBS data set. Thereafter, this file is updated when new information is submitted.

<u>NGS Survey Equipment Code:</u> A three-digit numeric identification code is assigned to each category of survey equipment, and within each category to specific instruments or other commonly used items. In particular, gravity instruments are assigned 001-029 survey equipment codes (see ANNEX F).

<u>Instrument Serial Number:</u> Assigned by the manufacturer, the serial number is the ultimate identifier of a specific instrument. Serial numbers are normally numeric; however, alphabetic characters are often used as prefixes, suffixes, etc. 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 serial number will be used together with the respective survey equipment code (see above) to create appropriate entries in the NGS Gravity Instrument File, to maintain these entries up to date, and to access this file for the retrieval of the respective calibration data in the course of routine processing of GRAV OBS data sets. It is therefore of utmost importance that the respective serial number be faithfully reproduced and that identical serial number representation be used consistently whenever reference is made to that specific instrument in any GRAV OBS data set.

OBSERVATION DATA RECORDS

30 Land Observation Record (Running Record)
32 Marine Observation Record
35 Comment Record

The observation data records, identified by *30*-series data codes, are listed above. The block diagrams illustrating the respective formats are given in the FORMAT DIAGRAMS. The purpose of the *30*-series records is to provide the means to record the observations carried out during a loop. Recall that in relative gravimetry a loop is a unit of field work consisting of a number of survey points connected by observations. A gravity loop usually begins and ends at control points (Base Stations) where gravity is either known or will be determined in this survey. A survey consists of one or more gravity loops. The observational sequence within a loop is referred to as a "running".

Submit a *30* record for every land observation carried out during the survey, regardless of its field acceptance or rejection status, but indicate on the record if the observation has been rejected. The *30* records must be submitted in the order that the survey points were observed. Table 10-2 shows a possible Land Gravity Observation Data Set.

Submit a *32* record for every marine observation carried out during a survey, regardless of its field acceptance or rejection status, but indicate on the record if the observation has been rejected. The *32* records must be submitted in the order in which the gravity observations were observed (i.e. in the direction of the trackline). If more than one observation is carried out at the same time (i.e. by more than 1 meter) they may be submitted in any consistant order. *30* and *32* records must not be mixed in the same survey. In the case of base ties to harbor stations or alongside observations, the *30* record must be used. The *32* record is to be employed only for data taken at sea and for which the assignment of Survey Point Serial Numbers (SPSN) and Archive Cross Referrence Numbers (ACRN) would not be appropriate. It is of course possible to have several surveys submitted at the same time, including both land and marine observations. Table 10-3 shows a possible data set structure which includes both land and marine observations.

Submit *35* record for any pertinent comments during a survey. Comments pertaining to severe weather conditions and equipment malfunction are considered appropriate.

TABLE 10-2
STRUCTURE OF A LAND GRAV OBS DATA SET

Data Set Identification Record

10 - Series Records		
20 - Series Records		
30 - Series Records	first	
40 - Series Records	loop	
30 - Series Records	second	First Survey
40 - Series Records	loop	
::::	::::	
::::	::::	
30 - Series Records	last	
40 - Series Records	loop in	
50 - Series Records	first survey	
10 - Series Records		
20 - Series Records		
30 - Series Records	first	
40 - Series Records	loop	
30 - Series Records	second	Second Survey
40 - Series Records	loop	(also last survey
		in this example)
::::	::::	
::::	::::	
30 - Series Records	last	
40 - Series Records	loop in	
50 - Series Records	survey	

Data Set Termination Record

Survey Point Serial Number: For the purpose of identifying the survey points of each survey in a concise and unique manner (e.g., on the respective *30* records), each point that is observed is assigned a survey-specific serial number in the range of 0001 to 9999. See Chapter 9 for a detailed explanation of the survey point numbering system.

Height of Instument (HI): For a land survey, the HI is defined to be the distance from the station mark to the instrument. For LaCoste & Romberg Model D and G gravity meters, this distance is measured to the bottom of the meter case.

TABLE 10-3
STRUCTURE OF A COMBINED LAND & MARINE GRAV OBS DATA SET

Records	Description
Data Set Identification Record	
10 Series Records *20* Series Records *30* and *35* Records *40* Series Records *50* Series Records	Land Observations (i.e. Base tie to shipboard gravity meter)
10 Series Records *20* Series Records *32* and *35* Records *40* Series Records	Marine Observations (gravity observations taken along trackline)
10 Series Records *20* Series Records *30* and *35 Records *40* Series Records *50* Series Records	Land Observations (i.e. Base tie to shipboard gravity meter)
Data set termination Record	

For a marine survey requiring the use of *32* records, the HI is defined to be the distance (vertically) above or below sea level to where the gravity meter is mounted. For La Coste & Romberg models meters, this distance is measured to the bottom of the stablized platform "bucket" which houses the gravity meter sensor.

The manufacturer will determine the appropriate place to measure to in the case of other instruments. This location should be noted with a *35* record, and in all cases remain unchanged during a survey.

A negative sign (-) indicates that the bottom of the meter is located below the survey point (land observation) or sea level (marine observation).

<u>Wind Code:</u> 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

<u>Sun Code:</u> A one-character numeric code, the purpose of which is to denote the approximate conditions of illumination prevailing during the course of an observation. The three sun codes are:

- 0 - More than 75% cloud cover
- 1 - Between 25 and 75% cloud cover
- 2 - Less than 25% cloud cover

Temperature of Air: The air temperature is recorded in first order gravimetry. This temperature is recorded in tenths of Celcius degrees. 14.3 degrees C would be recorded as 143.

Atmospheric Pressure: The atmospheric pressure is recorded in first order gravimetry. This pressure is recorded in millibars. Pressures measured in other units should be converted to millibars. 1 mbar is approximately equal to .75006 mm Hg.

Reading Quality Indicator: A qualitative appraisal of the reading should be included with each *30* record. This appraisal or indicator should be the field person's best estimate of the reading quality. The following should be used as general guide in deciding the most appropriate indicator:

Reading Variability

Indicator	Subjective Criteria
0	Steady (normal)
1	Slight variation
2	Moderate variation
3	Excessive variation
9	Tare suspected

LOOP TERMINATION RECORDS

40 Loop termination Record
45 Comment Record

The Loop Termination Record (*40*) is the record required to identify the completion of a gravity loop. It serves no other purpose. There are no other fields besides the sequence number and data code fields.

A *45* comment record should be submitted for any pertinent comments about a loop.

STATION INFORMATION RECORDS

50 Station Information Record
55 Comment Record

The *50* Station Information Record correlates a specific Survey Point Serial Number (SPSN) used within the survey to a station designation or name by which the station or survey point is commonly referred as well as with the station position and elevation.

A *50* record must be submitted in the station information data section for each SPSN used in the observation data section of a survey. In addition, the *50* record allows the inclusion of an Archival Corss Reference Number (ACRN) if known.

A *55* comment record should be submitted for any pertinent comments about a station. Additional information about the station name or location is considered appropriate.

Archival Cross Reference Number: The Archival Cross Reference Number (ACRN) is a unique alphanumeric identifying code assigned to each vertical and gravity control point used in the NGS. The ACRN is not generally made available, as a matter of practice, to the public. Thus, the use of ACRNs are expected to be specific only to NGS.

Designation: A 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 National Geodetic Survey, National Ocean Service, 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 survey point designation entered on the *50* record must be identical to the (primary) designation used to identify the same gravity control point in the companion GRAV DESC data set of the gravity 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 survey points which may have to be carried in the GRAV OBS data set but which do not appear in the companion GRAV DESC data set, i.e. Drift Station).

FORMAT DIAGRAMS

For each record which appears in a GRAV OBS data set (see Table 10-1), 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 entities 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.

Date Field Types:

1. Alpha Field (aa...a) - intended for a data item which is coded as a string of alphabetic, numeric, and 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 9 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 date items may be entered in these fields.

3. 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 "d" columns filled with zeros and any unused "f" columns either filled with blanks or zeros. When a negative number is entered, code the minus sign immediately preceding the leading digit.

4. 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, blank-fill any unused columbs 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.

5. 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 GRAV OBS data set. 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.

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

000010*AZ*GRAVOBS NGS   NATIONAL GEODETIC SURVEY                        19840906
000020*10*P02645        1984031919840320       12AZ    LMJNGS
000030*11*ARIZONA LAND SUBSIDENCE PROJECT
000040*15*GPS & LEVELING ALSO RUN ALONG SAME LINES
000050*20*014G081                   LACOSTE    G-METER     NGS
000060*21*G081              LACOSTE                AUSTIN TEXAS             1
000070*25*ONLY SUFFICIENT TABLE I VALUES FOR THIS SURVEY SUBMITTED
000080*22*25000002572350260000026753702700000277840028000002881430290000029844 70
000090*22*30000003087520310000031905903200000329367033000003396770340000034998 90
000100*23*G081        78    LACOSTE
000110*24*1.000259
000120*20*015D043                   LACOSTE    D-METER     NGS
000130*23*D043        81    LACOSTE
000140*24*1.2424
000150*30*   802      0G081          18403191515   292531002LMJ10423802
000160*30*   802      0D043           8403191530    10005502LMJ10423802
000170*30*   001     20G081          18403191559   293614002LMJ16423602
000180*30*   001     20D043           8403191610    10904402LMJ16423602
000190*30*   002     20G081          18403191623   294185002LMJ16523402
000200*30*   002     20D043           8403191625    11380302LMJ16523402
000210*30*   003     70G081          18403191640   294705002LMJ17623402
000220*30*   003     70D043           8403191650    11798002LMJ17623402 R
000230*35*THIS WAS A BAD READING.  OBSERVATION BEING REPEATED
000240*30*   003     70D043           8403191650    11799002LMJ17623402
000250*30*   802      0G081          18403200057   292523002LMJ25525202
000260*30*   802     0D043            8403200105    10003602LMJ25525202
000270*40*
000280*45*FIRST HALF OF LADDER SEQUENCE FINISHED
000290*30*   802      0G081          18403201549   292531002LMJ19524802
000300*30*   802      0D043           8403201601    10007902LMJ19524802
000310*30*   002     20G081          18403202124   294165002LMJ30725502
000320*30*   002     20D043           8403202132    11366502LMJ30725502
000330*30*   003     65G081          18403202155   294685002LMJ33025802
000340*30*   003     65D043           8403202203    11796002LMJ33025802
000350*30*   001     20G081          18403202211   293583502LMJ31525802
000360*30*   001     20D043           8403202220    10886102LMJ31525802
000370*30*   802      0G081          18403202247   292509002LMJ31126002
000380*30*   802      0D043           8403202253    09991302LMJ31126002
000390*40*
000400*50* 802AN 51                   CZ1510 3246360C 11136000C  463743I
000410*55*AN 51 IS THE BASE STATION FOR THIS SURVEY
000420*50* 001X 278                   CZ1034 3247480C 11137360C  457681I
000430*50* 002AL 49 USE               CZ1031 3248240C 11138060C  453266I
000440*50* 003Q 363                   CZ1032 3249180C 11138060C  456558I
000450*AZ*

00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

FIGURE 10-1 - Example of OBS Date Set

TABLE I

Milligal Values for LaCoste & Romberg, Inc. Model G Gravity Meter #130

Counter Leading*	Value in Milligals	Factor for Interval	Counter Reading*	Value in Milligals	Factor for Interval
000	000	1.04980			
100	104.98	1.04970	3600	3778.37	1.05025
200	209.95	1.04960	3700	3883.39	1.05040
300	314.91	1.04950	3800	3988.43	1.05030
400	419.86	1.04935	3900	4093.46	1.05040
500	524.80	1.04925	4000	4198.50	1.05045
600	629.73	1.04915	4100	4303.55	1.05055
700	734.64	1.04910	4200	4408.60	1.05065
800	839.55	1.04905	4300	4513.67	1.05075
900	944.46	1.04905	4400	4618.74	1.05080
1000	1049.36	1.04903	4500	4723.82	1.05085
1100	1154.26	1.04900	4600	4828.91	1.05090
1200	1259.17	1.04905	4700	4934.00	1.05090
1300	1364.07	1.04905	4800	5039.09	1.05085
1400	1468.97	1.04905	4900	5144.17	1.05085
1500	1573.88	1.04910	5000	5249.26	1.05075
1600	1678.79	1.04915	5100	5354.34	1.05080
1700	1783.70	1.04920	5200	5459.42	1.05085
1800	1888.62	1.04925	5300	5564.50	1.05080
1900	1993.55	1.04940	5400	5669.58	1.05075
2000	2098.49	1.04950	5500	5774.66	1.05060
2100	2203.44	1.04955	5600	5879.72	1.05050
2200	2308.39	1.04965	5700	5984.77	1.05040
2300	2413.36	1.04970	5800	6089.81	1.05025
2400	2518.33	1.04975	5900	6194.84	1.05010
2500	2623.30	1.04975	6000	6299.85	1.05000
2600	2728.28	1.04980	6100	6404.84	1.04985
2700	2833.26	1.04985	6200	6509.83	1.04965
2800	2938.25	1.04995	6300	6614.79	1.04940
2900	3043.24	1.05005	6400	6719.73	1.04915
3000	3148.25	1.05010	6500	6824.65	1.04885
3100	3253.26	1.05015	6600	6929.53	1.04855
3200	3358.27	1.05020	6700	7034.39	1.04820
3300	3463.29	1.05025	6800	7139.21	1.04785
3400	3568.32	1.05025	6900	7243.99	1.04750
3500	3673.34	1.05025	7000	7348.74	

NOTE: Right hand wheel on counter indicates approximately 0.1 milligal.

FIGURE 10-2 - Example of LaCoste & Romberg Internal Values

Data Set IdentificationRecord. This must be the first record of every data set submitted. A data set may be submitted either as a deck of cards or as a magnetic tape file containing formatted records. Magentic tape is preferred; use punched cards for small, isolated jobs only.

000000 123456	0001 7890	1111 1234	1111 5678	122222 901234	222223333333333444444444455555555556666666 567890123456789012345678901234567890123456	666777 789012	77777778 34567890
	Data Set Identification			Name of Submitting Agency or Firm			
Sequence Number - must be 000010 on this record. Increment by 10 on successive records to allow for insertions.	Job Code - preceded and followed by asterisk.	Data Class - GRAV for Gravity control data.	Data Type - OBS for field observation data.	Abbreviation - must be unique. Enter the symbol listed in ANNEX C. See footnote for other agencies or firms	Full Name		Date Data Set Created (e.g. date this record keyed) Century, year, month, day (CCYYMMDD). If day is unknown, leave last columns blank. If month is unknown, leave last four columns blank.
000010	*CA*	GRAV	OBS	USGS	US GEOLOGICAL SURVEY		19820512
iiiiii	saas	aaaa	aaaa	aaaaaa	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa	bbbbbb	iiiiiiii

Important: To insureuniqueness, agencies or firms not listed in ANNEX C must have their proposed abbreviation symbol accepted by NGS prior to first submittal of data - see ANNEX K.

10 Survey Information Record. This must be the leading record of each Gravity Survey included in the job - note that a GRAV OBS job consists of one or more Gravity Surveys. A code is provided to indicate whether the survey is original or not - see footnote.

Columns	Field	Example	Format
000000 / 123456	Sequence Number Increment by 10 on successive records to allow for insertions.	nnnnnn	iiiiii
0001 / 7890	Data Code - preceded and followed by asterisk. (*10* - Survey Information Record)	*10*	siis
11111111 / 12345678	Agency - specific pointer to its own archives - usually given as an "accession number" (or other cataloguing symbol) which identifies the block of data, possibly supplemented by a further "line" or "part" designation. Accession Number	P02618	aaaaaaaa
1222 / 9012	Line/Part (Optional)	1	aaaa
2 / 3	Resurvey Code - See footnote.	R	a
22222233 / 45678901	Date Field Operations Commenced Century, year, month, day. (CCYYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.	19820124	iiiiiiii
33333333 / 23456789	Date Field Observations Terminated Century, year, month, day (CCYYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.	19820413	iiiiiiii
444444 / 012345			bbbbbb
44 / 67	Order and Class of Survey - See table above.	11	ii
445555 / 890123	State or Country Code - See ANNEX A. Enter the code(s) for the state (or country) in which the line begins (and into which it extends).	CA	aaaaaa
555 / 456	Initials of Chief of Party - i.e., person responsible for the survey, leave blank if unknown.	RWJ	aaa
55566666666667777777 / 78901234567890123456	Agency which made the observations. For agencies or firms listed in ANNEX C, enter the respective six-character abbreciation. For others enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.	USGS	aaaaaaaaaaaaaaaaaaaa
7778 / 7890			bbbb

Order and Class of Survey						
Order	1st			2nd	3rd	Lower
Class	*	I	II	**	**	**
Code	10	11	12	20	30	40

* Class unspecified
** No class subdivision

Resurvey Code: Enter R if resurveyed over previously established control loop; leave blank otherwise.

11 Survey Title Record and *12*, *13*, *14* Survey Title Continuation Records (Optional).

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

Columns	Field	Description
000000 123456	Sequence Number	Increment by 10 on successive records to allow for insertions.
0001 7890	Data Code	*11*, *12*, *13*, *14* Survey Title Records
1111111111222222222233333333334444444444555555555566666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890	Survey Title	Survey Title - use *12*, *13*, *14* Survey 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 survey 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* Survey Title and Survey 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 Survey title in the interest of fitting the entire title on the *11* Survey Title Record, if possible.

```
nnnnnn*11*REOBSERVATIONS OF GRAVITY STATIONS FOR EARTHQUAKE STUDIES, CA
nnnnnn*12*WISTER SOUTH TO COLEXICO, DIXIELAND EAST VIA EL CENTRO TO HOLTVILLE
iiiiiisiisaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
00000000011111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

15 Comment Record (Optional). Use this record for any comments pertinent to the survey. If the comment(s) exceed 70 characters, use another *15* record for continuation, any number of *15* records is allowed. Do not divide words between consecutive *15* records.

000000 123456	0001 7890	11111111122222222223333333333444444444455555555556666666666777777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Sequence Number Increment by 10 on successive records to allow for insertions.	Data Code ("15" - Comment Record)	Comment
nnnnnn	*15*	LEVELS OBSERVED OVER THIS SURVEY
iiiiii	siis	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
000000 123456	0001 7890	11111111122222222223333333333444444444455555555556666666666777777777778 1234567890123456789012345678901234567890123456789012345678901234567890

20 Instrument Information Record. Submit this record for every instrument (identified by the respective Survey Equipment Code and Instrument Serial Number).

000000 123456	0001 7890	111 123	1111112222 4567890123	2222223 4567890	33333333344 12345678901	444444445555 234567890123	55555566666666667777 45678901234567890123	7777778 4567890
Sequence Number Increment by 10 on successive records to allow for insertions.	Data code (*20* - Instrument Information Record)	NGS Survey Equipment Code - see ANNEX F.	Instrument Serial Number - alphanumeric, left-justified.		Manufacturer - examples: La Coste Worden	Model of Type - examples: G-meter D-meter	Agency which owns or has the custody of the instrument. For agencies or firms listed in ANNEX C, enter the respective six-character abbreviation. For others, enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.	
nnnnnn	*20*	014	G130		LACOSTE	G-METER	DMA	
iiiiii	siis	iii	aaaaaaaaaa	bbbbbbb	aaaaaaaaaaa	aaaaaaaaaaaa	aaaaaaaaaaaaaaaaaaaa	bbbbbbb
000000 123456	0001 7890	111 123	1111112222 4567890123	2222223 4567890	33333333344 12345678901	444444445555 234567890123	55555566666666667777 45678901234567890123	7777778 4567890

21 Instrument Calibration Header Record. This record must be submitted for every instrument during a survey if, as determined by the Instrument Type as well as intended survey accuracy, it is appropriate. This record must immediately precede the *22* record(s) which it identifies. Specifically, this applies to La Coste and Romberg G-Meters.

Columns	Field description	Sample	Type
1–6	Sequence Number Increment by 10 on successive records to allow for insertions.	nnnnnn	iiiiii
7–10	Data Code (*21* - Instrument Calibration Header Record)	*21*	iiii
11–20	Instrument Serial Number - alphanumeric, left-justified.	G130	aaaaaaaaaa
21–26	Date Determined - year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.	561010	iiiiii
27–46	Agency which determined or performed the calibration. For agencies or firms listed in ANNEX C, enter the respective six-character abbreviation. For others, enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.	LACOSTE	aaaaaaaaaaaaaaaaaaaa
47–66	Location where calibration was performed.	AUSTIN TEXAS	aaaaaaaaaaaaaaaaaaaa
67–78			bbbbbbbbbbii
79–80	Calibration Serial Number- Job specific identifier for corresponding observations.	30	ii

22 Instrument Calibration Information Record. Submit as many of these records, in proper order (see text), for each instrument when required. For La Coste and Romberg G-Meters this information will normally be extracted from the Table I provided by the manufacturer. For others meters or for alternate calibration procedures, this information represents the conversion from some observable (Dial Units, Volts, etc.) to Microgals.

Columns	Description	Example	Format
000000 123456	Sequence Number Increment by 10 on successive records to allow for insertions.	nnnnnn	iiiiii
0001 7890	Data Code (*22* - Instrument Calibration Information Record)	*22*	siis
1111111 1234567	Counter Dial Units - The observed values from the gravity meter during the calibration. The first entry on the first *22* record must be the lowest counter dial unit encountered during calibration (see text chapter 10). Decimal point implied after column 14.	0000000	fffdddd
1122222 8901234	Mgal Value - Corresponding Mgal Value for the preceding Counter Dial Unit. Decimal point implied after column 21.	0000000	fffdddd
2222233 5678901	Counter Dial Units Decimal point implied after column 28.	0100000	fffdddd
3333333 2345678	Mgal Value Decimal point implied after column 35.	0109980	fffdddd
3444444 9012345	Counter Dial Units Decimal point implied after column 42.	0200000	fffdddd
4444555 6789012	Mgal Value Decimal point implied after column 49.	0209950	fffdddd
5555555 3456789	Counter Dial Units Decimal point implied after column 56.	0300000	fffdddd
6666666 0123456	Mgal Value Decimal point implied after column 63.	0314310	fffdddd
6667777 7890123	Counter Dial Units Decimal point implied after column 70.	0400000	fffdddd
7777778 4567890	Mgal Value Decimal point implied after column 77.	0419860	fffdddd

23 Instrument Scale Factor Header Record. - Submit this record for every instrument used during the survey. If the observations do not require scaling, then a scale factor of 1.000 should be submitted.

000000 123456	0001 7890	1111111112 1234567890	222222 123456	22233333333334444444 78901234567890123456	4445555 7890123	55 45	5555666 6789012	666666677777777778 345678901234567890
Sequence Number Increment by 10 on successive records to allow for insertions.	Data Code ("23" - Instrument Scale Factor Header Record)	Instrument Serial Number - alphanumeric, left-justified.	Date Determined - year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.	Agency which determined or performed the scale factor determination. For agencies or firms listed in ANNEX C, enter the respective six-character abbreviation. For others, enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.	Lowest value in counter dial units for which this scale factor is appropriate.		Highest value in counter dial units for which this scale factor is appropriate.	
nnnnnn	*23*	G130	661018	LACOSTE	0000000		7000000	
iiiiii	siis	aaaaaaaaaa	iiiiii	aaaaaaaaaaaaaaaaaaaa	iiiiiii	bb	iiiiiii	bbbbbbbbbbbbbbbbbb
000000 123456	0001 7890	1111111112 1234567890	222222 123456	22233333333334444444 78901234567890123456	4445555 7890123	55 45	5555666 6789012	666666677777777778 345678901234567890

__*24* Instrument Scale Factor Record.__ - Submit this record for each instrument and counter dial unit range as specified by the proceding *23* record. Note: sufficient *23* and *24* records must be provided in the job to totally cover the entire range of counter dial values encountered within the survey. More than one *23* and *24* records may be included provided that the ranges of scale factors as stated on *23* records do not overlap.

000000 123456	0001 7890	111111111222 123456789012	22 34	222223333333 567890123456	33344444444445555555555666666666677777777778 78901234567890123456789012345678901234567890
__Sequence Number__ Increment by 10 on successive records to allow for insertions.	__Data Code__ (*24* - Instrument Scale Factor Record)	__Scale Factor__ - The scale factor is used in conjunction with, or in lieu of, values supplied in the *21* and *22* records. The use of scale factors and interval values is extremely instrument dependent. The end result however should be the conversion of observations to mgal values.		__Standard Deviation of Scale Factor__ - complete this field if known.	
nnnnnn	*24*	1.000082		0.000003	
iiiiii	siis	ffffffffffff	bb	ffffffffffff	bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
000000 123456	0001 7890	111111111222 123456789012	22 34	222223333333 567890123456	33344444444445555555555666666666677777777778 78901234567890123456789012345678901234567890

***25* Comment Record (Optional).** Use this record for any comments pertinent to an instrument. If the comment(s) exceed 70 characters, use another *25* record for continuation, any number of *25* records is allowed. Do not divide words between consecutive *25* records.

000000 123456	0001 7890	1111111111222222222233333333334444444444555555555566666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Sequence Number Increment by 10 on successive records to allow for insertions.	Data Code (*25* - Comment Record)	Comment
nnnnnn	*25*	TABLE I VALUES WILL BE VERIFIED AFTER THIS SURVEY
iiiiii	siis	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
000000 123456	0001 7890	1111111111222222222233333333334444444444555555555566666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890

30 Land Observation record. (Running Record) Submit this record for every observation. A separate *30* record is required for each instrument used at a particular location. Any instrument may be indicated on the *30* record providing *20*, *23* and *24* records for that instrument have been recorded prior to the *30* record.

Field	Entry	Format
Sequence Number – Increment by 10 on successive records to allow for insertions.	nnnnnn	iiiiii
Data Code (*30* – Land Observation Record (Running Record))	*30*	iiii
Survey Point Serial Number (SPSN) – see Chapter 8. Must be same as SPSN used in GRAV DESC data set and on *80* record.	0732	iiii
Height of Instrument (HI) – (mm) – Distance from bottom of meter to control point. (–) indicated in column 17 for stations above instrument. Right justified.	70	iiiii
Instrument Serial Number – Number must agree with A *20* record submitted with survey data with the job.	G130	aaaaaaaaaa
Instrument Calibration Serial Number - Must correspond with calibration information on *21* recd.		ii
Date of Reading – year, month, day (YYMMDD)	800202	iiiiii
Time of Reading	210932	iiii
Reading of instrument – Decimal implied after column 53. For relative instruments, reading is dial reading. For Absolute, gravity value obtained.	27732400	ffffffff
Wind and Sun Code – see footnote	2	ddd
Initials of Observer	RHJ	aaa
Temperature of Air (Tenths – Degree Celsius)	201	iii
Atmospheric Pressure (millibar)	10030	iiiii
		bbbbbbbbbbb

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.
Reading Quality Indicator: 0 - steady (normal), 1 - slight variation, 2 - moderate variation, 3 - excessive variation, 9 - tare suspected

32 Marine Observation Record. - Submit this record for every observation taken aboard ship. A separate *32* record is required for each instrument used. Any instrument may be indicated on the *32* record providing *20*, *23* and *24* records for that instrument have been recorded prior to the *32* record.

Columns	Field	Example	Format
1–6	Sequence Number – Increment by 10 on successive records to allow for insertions.	nnnnnn	iiiiii
7–10	Data Code (*32* - Marine Observation Record)	*32*	siis
11–20	Instrument Serial Number - Same format as *30* record.	S51	aaaaaaaaaa
21–24	Instrument Calibration Serial Number - See footnote	10	iiii
25–32	Latitude - (±DDMMSSs) - Same as *50* record. Decimal implied between column 29 and 30.	-2045530	fffffffd
33	Latitude Accuracy Code	J	a
34–42	Longitude - (±DDDMMSSs) - Same as *50* record. Decimal implied between column 39 and 40.	13015455	ffffffffd
43	Longitude Accuracy Code	J	a
44–49	Depth - (MMMMMm) - Depth of bottom surface below sea level. Decimal implied between columns 48 and 49.	24334	fffffd
50	Depth Accuracy Code	K	a
51–56	Height of Instrument (HI) - (mm) - See text.	5100	iiiiii
57–62	Date of Reading - year, month, day (YYMMDD)	860829	iiiiii
63–68	Time of Reading - hours, minutes, seconds (HHMMSS)	080110	iiiiii
69–78	Reading of Instrument - Decimal implied between column 75 and 76.	2730440	ffffffdddb
79–80	Acceptance Criteria - Reject obs if "R". Accept if blank.		ba

Accuracy Codes (Depth, Latitude, Longitude)		
Accuracy Range (Meters)		
Low	Code	High
-	J	1
1	K	10
10	L	25
25	M	50
50	N	100
100	O	200
200	P	300
300	Q	500
500	R	-

Instrument Calibration Serial Number - Must correspond with Calibration Information provided in *21* and *22* records.

35 Comment Record (Optional). Use this record for any comments pertinent to the observation. If the comment(s) exceed 70 characters, use another *35* record for continuation, any number of *35* records is allowed. Do not divide words between consecutive *35* records.

000000 123456	0001 7890	1111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Sequence Number Increment by 10 on successive records to allow for insertions.	Data Code (*35* - Comment Record)	Comment
nnnnnn	*35*	NECESSARY TO CHANGE BATTERY AT 1435 HRS GCT
iiiiii	siis	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
000000 123456	0001 7890	1111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890

40 Loop Termination Record. This must be the last record of each gravity loop within every data set submitted.

000000 123456	0001 7890	11111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Sequence Number Increment by 10 on successive records to allow for insertions.	Data Code (*40* - Loop Termination Record)	
nnnnnn	*40*	
iiiiii	siis	bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
000000 123456	0001 7890	11111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890

45 Comment Record (Optional). Use this record for any comments pertinent to the loop. If the comment(s) exceed 70 characters, use another *45* record for continuation, any number of *45* records is allowed. Do not divide words between consecutive *45* records.

000000 123456	0001 7890	1111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Sequence Number Increment by 10 on successive records to allow for insertions.	Data Code ("45" - Comment Record)	Comment
nnnnnn	*45*	CHECK THIS LOOP
iiiiii	siis	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
000000 123456	0001 7890	1111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890

50 Station Designation Record. Submit this record once for each SPSN used during a gravity survey.

Columns	Field
73–80	
72	Elevation Code - see box
63–71	**Elevation** - (MM) Most accurate existing elevation known at time of survey, expressed in millimeters. (-) in column 65 indicates below sea level datum. Right justified.
62	Longitude Code - see box
53–61	**Longitude** - (±DDDMMSSs) - Longitude expressed as ± degrees, minutes, seconds and tenths of seconds. (-) indicates East. Decimal implied after column 62.
52	Latitude Code - see box
45–52	**Latitude** - (±DDMMSSs) - Latitude expressed as ± degrees, minutes, seconds and tenths of seconds. (-) indicates South. Decimal implied after column 52.
40–45	**Archival Cross Reference Number (ACRN)** - NGS specific, complete if known, otherwise leave blank.
15–39	**Designation** - must not exceed 25 characters. This is the primary designation which will be associated with the gravity control point for publication purposes. In every case, the designation must be edited in conformity with Guidelines for Survey Point Names and Designations (ANNEX D). The designation entered in this field must be identical (character for character) with the designation given for the same point in the corresponding GRAV DESC data set.
11–14	**Survey Point Serial Number (SPSN)** - see chapter 9. Must be same as SPSN used in GRAV DESC data set.
7–10	**Data Code** ("*50*" - Station Designation Record)
1–6	**Sequence Number** Increment by 10 on successive records to allow for insertions.

Accuracy Codes for Elevation

Accuracy Range (Meters)

Low	Code	High
-	I	.01
.01	J	1
1	K	10
10	L	25
25	M	50
50	N	-

Accuracy Codes for Latitude, Longitude

Accuracy Range (Arc Min., Sec.)

Low	Code	High
-	A	1"
1"	B	10"
10"	C	1'
1'	D	5'
5'	E	10'
10'	F	20'
20'	G	-

Example: nnnnn*50*1513J 1083 RESET 1973 DR0732 3239452A 1115300A- 34700K

55 Comment Record (Optional). Use this record for any comments pertinent a station. If the comment(s) exceed 70 characters, use another *55* record for continuation, any number of *55* records is allowed. Do not divide words between consecutive *55* records.

000000 123456	0001 7890	11111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Secuence Number Increment by 10 on successive records to allow for insertions.	Data Code (*55* - Comment Record)	Comment
nnnnnn	*55*	NO ACRNS AVAILABLE FOR THIS SURVEY
iiiiii	siis	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
000000 123456	0001 7890	11111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890

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

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Job Code - preceded and followed by asterisk.

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

Data Set Structure: a GRAV OBS Data Set consists of one or more gravity surveys. A gravity survey consists one or more gravity loops.

Data Set Identification Record	
10 - series records *20* - series records *30* - series records *40* - series records *50* - series records	FIRST SURVEY
10 - series records *20* - series records *30* - series records *40* - series records *50* - series records	SECOND SURVEY
:::: ::::	:::: ::::
10 - series records *20* - series records *30* - series records *40* - series records *50* - series records	LAST SURVEY
Data Set Termination Record	

```
nnnnn*CA*
iiiiisaasbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Chapter 11

ADJUSTED GRAVITY CONTROL (GRAV ADJU) DATA

INTRODUCTION

This chapter provides detailed specifications and instructions for the coding and keying of adjusted gravity control (GRAV ADJU) data. As explained in Chapter 9, GRAV ADJU data can only be accepted for inclusion into the NGS gravity working file. Since the connecting observations are not available these adjusted values cannot be fully verified and are not appropriate for entry into the NGS gravity data base. GRAV DESC data are not required to accompany GRAV ADJU data, since GRAV ADJU data will not be entered into the NGS gravity data base.

The NGS gravity data base contains values for control points which have been fully verified by NGS and for which NGS has the appropriate descriptions. The gravity working file contains values for survey points that cannot be verified and/or for which NGS does not have the descriptions. The NGS gravity working file is none-the-less an extremely useful file, one on which most geoid modelling and evaluation depend. The NGS gravity data base, however, contains all information about stations and observations and is much more informative when temporal or localized studies are conducted. The rather limited definition of a data base by NGS should not be construed by a potential user that the working file is a substandard file.

The format for the submittal of GRAV ADJU data is significantly different from the formats for the submittal of GRAV OBS and GRAV DESC data. The general format of GRAV ADJU data is the same as that specified by the Department of Defense (DOD) Gravity Services Branch (Gravity Station Data Card Format). A copy of the DoD Gravity Coding Sheet is included in Figure 11-1 at the end of the chapter for reference purposes only. Figure 11-2 should be used when submitting data to NGS, since it reflects the actual format used at NGS.

NGS employs a subset of the strict DoD format. The following is a discussion of those elements of the DoD format which NGS employs. Some of the elements of the strict DoD format are not appropriate for general users and depend on agency policy.

A block diagram illustrating the respective format has been prepared to serve as a model for the Adjusted Gravity Station Data Record. A record is a string of characters containing data coded into a specific format. Every record in a GRAV ADJU data set consists of 80 characters called columns (standard punch card format). 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 in which the data items are converted into strings of alphanumeric characters. The set of rules by 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.

ADJUSTED GRAVITY STATION DATA RECORD

The Adjusted Gravity Station Data Record is the only record type allowable for submission of ADJU data for inclusion into the gravity working file. The entries on this record are for the most part self-explanatory. Those which are either Department of Defense specific or require elaboration will be explained in greater detail.

SECURITY CLASSIFICATION

This code identifies proprietary or sensitive data. The following codes should be used:

U or blank = Unclassified material
F = Material classified FOR OFFICIAL USE ONLY

The following codes should be used where DoD classified data are involved:

C = Material classified CONFIDENTIAL
S = Material classified SECRET

As a general policy, NGS will only accept classified data on a case by case basis.

SECURITY CONTROL

The security control code identifies the appropriateness of data dissemination to the public. The general submission of data to NGS requires that this data field be either left blank or the code 4 used. The remaining codes are DoD specific and should not be used by other agencies. The following are the codes:

0 or Blank = No Security Control
1 = (DoD specific) Limited Dissemination, to full-time employees of Department of Defense, Central Intelligence Agency, and Department of Energy
2 = (DoD specific) Not releasable to foreign nationals
3 = (DoD specific) Limited dissemination, not releasable to foreign nationals
4 = Special release from originating agency required for dissemination to any third party
5 = (DoD specific) Modified Handling authorized (includes Foreign "restricted," NATO, CENTO, SEATO, etc.)

GEOGRAPHIC UNITS

The geographic units code defines the units of the geographic coordinates of the gravity station in degrees and decimal minutes or degrees, minutes and seconds or decimal degrees. The following codes should be used:

0 or blank = degrees and minutes to .01 minute
1 = degrees, minutes and seconds (The preferred NGS Geographic Units)
2 = degrees to .0001 degree

TYPE of ELEVATION

The type of elevation code indicates where the adjusted value is located. The following codes should be used:

1 = land
2 = subsurface
3 = ocean surface
4 = ocean submerged
5 = ocean bottom
6 = lake surface (above sea level)
7 = lake bottom (above sea level)
8 = lake bottom (below sea level)
9 = lake surface (above sea level) with lake bottom below sea level
A = lake surface (below sea level)
B = lake bottom (surface below sea level)
C = ice cap (bottom below sea level)
D = ice cap (bottom above sea level)
E = helicopter gravity survey over either land or ocean.

ELEVATION UNITS

The elevation unit code defines the units of elevation in meters, feet, or fathoms. The following codes should be used:

0 or blank = meters (the preferred units of measure for NGS)
1 = feet
2 = fathoms

ELEVATION

The elevation is the height of a gravity station above the geoid (approximately sea level), except when the TYPE OF ELEVATION (column 21) is coded as 3, 4, or 5. When the TYPE OF ELEVATION is coded as 3, 4, or 5 the elevation will be the depth of the ocean.

SUPPLEMENTAL ELEVATION

The supplement elevation will be the depth of instrument, lake, or ice, positive downward from the surface. The SUPPLEMENTAL ELEVATION should be used only if the TYPE of ELEVATION (column 21) is coded as a 2, 4, 6 through 9, or A through E (see ANNEX O). In helicopter gravity surveys, the supplemental elevation is the flying height of the helicopter above sea level.

ADJUSTED GRAVITY

Adjusted gravity is the value of gravity, based on IGSN-71 or the U.S. Absolute Gravity Datum, at a specific location. DoD refers to this field as "Observed gravity" on the DoD Gravity Coding sheet (Figure 11-1). The value to be coded in this field is the adjusted gravity value minus 976000.0 milligals.

FREE-AIR ANOMALY

A gravity anomaly is the difference between an adjusted gravity value which has been reduced to an equipotential surface known as the geoid and the corresponding normal gravity value on an ellipsoid. The ellipsoid is chosen so as to be a best fit to the geoid. A free-air anomaly is the difference between an adjusted gravity value which has been reduced to sea level (in an approximation of the geoid surface) and the corresponding normal gravity value on the reference ellipsoid. The correction for the sea level height of the gravity station (+0.3086 milligals/meter) is called the free-air correction. Because the actual vertical gravity gradient at the gravity station is usually not known, the normal ellipsoidal gravity gradient is used for the free-air correction.

$$A_{fa} = (g_a + f_a) - \gamma$$

where A_{fa} = free-air anomaly
g_a = adjusted gravity value
f_a = free-air correction, which is +0.3086 milligals/meter
γ = gravity on the ellipsoid

The gravity formula of the Geodetic Reference System of 1967 is used for the calculation of gravity on the ellipsoid.

$$\gamma = 978031.85\ (1 + 0.00527\ 8895\ \sin^2\phi\ + 0.00002\ 3462\ \sin^4\phi)\text{milligals.}$$

where ϕ is the geodetic latitude of the gravity station.

The computation of free-air anomalies with various types of observations is given in the Anomaly Computation Chart (ANNEX O).

BOUGUER ANOMALY

The Bouguer anomaly is derived from the free-air anomaly by subtracting the gravitational attraction of an infinite plate mass between the gravity station and sea level. With an assumed crustal density of 2.67 g/cm, the Bouguer correction is 0.1119 milligals/meter of station elevation (mean sea level height). A simple Bouguer anomaly assumes that the mass between the gravity station and the geoid is an infinite flat plate with no density variations. It is calculated by:

$$A_b = (g_a + f_a - S) - \gamma$$

where A_b = Simple Bouguer Anomaly
g_a = adjusted gravity
f_a = free-air correction
S = Bouguer plate correction, which is 0.1119 milligals/meter times the elevation for an assumed crustal density of 2.67 g/cm
γ = gravity on the ellipsoid

The computation of Simple Bouguer Anomalies with various types of observations are given in the Anomaly Computation Chart (ANNEX O).

Because the mass between the gravity station and the sea level is not flat, the plate correction can be supplemented by a terrain correction. This correction is always positive and accounts for the actual topography surrounding the gravity station. An anomaly derived this way is known as either a terrain corrected Bouguer Anomaly or a complete Bouguer Anomaly and is calculated by:

$$A_c = (g\ + f\ - S + T) - \gamma$$

where A_c = complete Bouguer Anomaly
T = Terrain Correction

An Isostatic Anomaly is obtained when corrections for the density variations in the crust and upper mantle are added to the Bouguer Anomaly. If the Bouguer Anomaly included a terrain correction, the derived Isostatic Anomaly is a Terrain Corrected Isostatic Anomaly. These anomalies are calculated by:

$$A_i = (g_a + f_a - S + I) - \gamma$$
$$A_{it} = (g_a + f_a - S + I + T) - \gamma$$

where A_i = Isostatic Anomaly
A_{it} = Terrain corrected Isostatic Anomaly
I = Isostatic Correction

ISOSTATIC ANOMALY OR TERRAIN CORRECTION CODE:
The purpose of this field is to indicate which type of anomaly is in the Bouguer Anomaly field. The following codes should be used:

0 = Bouguer Anomaly.
1 = Terrain corrected Bouguer Anomaly.
2 = Isostatic anomaly.
3 = Terrain corrected Isostatic Anomaly.

SOURCE CODE
The source code is DoD specific and is assigned by DoD. Other submitting agencies should leave this field blank.

BASE REFERENCE STATION CODE
The base reference station code is used to identify the base station location used to determine the adjusted value of the gravity. This field is DoD specific and should be left blank by agencies outside of DoD. Agencies familiar with DoD policy may choose to use this field. Its use, however, is explicitly optional.

BASE REFERENCE SITE
The base reference site identifies the occupied point at the base station location. This field is DoD specific and should be employed only by DoD or agencies familiar with DoD policy.

GRAVITY STATION NUMBER
A gravity station number is assigned to each station within one source code. The gravity station number basically serves the same purpose as the SPSN for a GRAV OBS data set. Its use is agency specific and optional for the purpose of transmitting data to NGS.

FILE MAINTENANCE
This code is inactive and should be left blank.

ESTIMATION STANDARD DEVIATION FREE-AIR ANOMALY AND BOUGUER ANOMALY
This value is an estimation of the standard deviation of the Bouguer Anomaly. Standard Deviation (Error) connotes that there is a 68% probability that the free-air or Bouguer anomalies will fall between the indicated + or - values: e.g., if the free-air anomaly is 10 milligal with a ±2 milligal error or standard deviation, then there is 68% probability that the value lies between 8 and 12 mgals.

FORMAT DIAGRAM

For the Adjusted Gravity Station Data record (see Table 11-2), a block diagram has been prepared to illustrate the format. This 'format diagram' has been designed to fulfill the following objectives:

1. Each record is 80 characters long (standard punched card image).

2. Each record has 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 entities 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 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 9 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. Floating-Point Field (ff...fdd...d) - intended for a data item that 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 "d" columns filled with zeros and any unused "f" columns filled with blanks. When a negative number is entered, code the minus sign immediately preceding the leading digit.

4. 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, blank-fill any unused columns on the left. In the case of 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.

Required Data: In general, only those records which are applicable to the data at hand should be included in a GRAV ADJU data set. The character fields intended for data items which are essential have been shaded on the format diagram: 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.

ADJUSTED GRAVITY STATION DATA RECORD. Submit this record for each adjusted gravity station, for which connecting observations are not available, for inclusion into the NGS gravity working file.

Columns	Description	Example	Format
01	Security Classification (See Chapter 11)		a
02	Security Control (See Chapter 11)		i
03	Geographic Units (See Chapter 11)	1	i
04–10	Latitude - Sign of Latitude in Column 4 (- for South) Decimal Point is implied: after Column 6 for Decimal Degrees after Column 8 for Degrees and Minutes after Column 10 for Degrees, Minutes and Seconds	555959	iiiiiii
11			b
12–19	Longitude - Sign of Longitude in Column 12 (- for West) Decimal Point is implied: after Column 15 for Decimal Degrees after Column 17 for Degrees and Minutes after Column 19 for Degrees, Minutes and Seconds	-1620231	iiiiiiii
20			b
21	Type of Elevation (See Chapter 11)	1	a
22	Elevation Units - 0=meters, 1=feet, 2=fathoms	0	i
23–29	Elevation Decimal Point is implied after Column 28 This field will contain Depth of Ocean (Positive Downward) if Column 21 contains 3, 4 or 5	5505	ffffffd
30			b
31–35	Supplemental Elevation Depth of Instrument, Lake or Ice. Positive Downward from Surface		iiiii
36			b
37–42	Adjusted Gravity Adjusted Gravity Value - 976000.00 milligals Decimal Point is implied after Column 40	561320	ffffdd
43			b
44–48	Free-Air Anomaly in milligals Decimal Point is implied after Column 47	221	ffffd
49			b
50–54	Bouguer Anomaly in milligals Decimal Point is implied after Column 53	258	ffffd
55			b
56	Isostatic Anomaly or Terrain Correction (See Chapter 11)	0	a
57			b
58–61	Source Code - DoD Specific (Optional) A Source Code Assigned by the Submitting Agency		aaaa
62			b
63–66	Base Reference Station DoD Specific (Optional)		aaaa
67	Base Reference Site DoD Specific (Optional)		a
68			b
69–72	Gravity Station Number - (Optional) The Sequence Number of Each Station within a Survey	0932	iiii
73			b
74	File Maintenance DoD Specific (Optional)		a
75			b
76–77	Standard Deviation Free-Air Anomaly - Estimate of the standard deviation of the free-air anomaly in milligals	02	ii
78			b
79–80	Standard Deviation Bouguer Anomaly - Estimate of the standard deviation of the bouguer anomaly in milligals	02	ii

ANNEX B

STATE PLANE COORDINATES (SPC) ZONE CODES

Text ‘ ’ or ‘1Z’ in the Zone column indicates zone covers an entire state.

SPC	ZONE	CODE
AL	E	0101
	W	0102
AK	1	5001
	2	5002
	3	5003
	4	5004
	5	5005
	6	5006
	7	5007
	8	5008
	9	5009
	10	5010
AZ	E	0201
	C	0202
	W	0203
AR	N	0301
	S	0302
CA	1	0401
	2	0402
	3	0403
	4	0404
	5	0405
	6	0406
CO	N	0501
	C	0502
	S	0503
CT		0600
DE		0700
FL	E	0901
	W	0902
	N	0903
GA	E	1001
	W	1002
HI	1	5101
	2	5102
	3	5103
	4	5104
	5	5105
ID	E	1101
	C	1102
	W	1103
IL	E	1201
	W	1202
IN	E	1301
	W	1302
IA	N	1401
	S	1402
KS	N	1501
	S	1502
KY	1Z	1600
	N	1601
	S	1602
LA	N	1701
	S	1702
	SH	1703
ME	E	1801
	W	1802
MD		1900
MA	M	2001
	I	2002
MI	N	2111
	C	2112
	S	2113
MN	N	2201
	C	2202
	S	2203
MS	E	2301
	W	2302
MO	E	2401
	C	2402
	W	2403
MT		2500
NE		2600
NV	E	2701
	C	2702
	W	2703
NH		2800
NJ		2900
NM	E	3001
	C	3002
	W	3003
NY	E	3101
	C	3102
	W	3103
	L	3104
NC		3200
ND	N	3301
	S	3302
OH	N	3401
	S	3402
OK	N	3501
	S	3502
OR	N	3601
	S	3602
PA	N	3701
	S	3702
RI		3800
SC		3900
SD	N	4001
	S	4002
TN		4100
TX	N	4201
	NC	4202
	C	4203
	SC	4204
	S	4205
UT	N	4301
	C	4302
	S	4303
VT		4400
VA	N	4501
	S	4502

SPC	ZONE	CODE
WA	N	4601
	S	4602
WV	N	4701
	S	4702
WI	N	4801
	C	4802
	S	4803
WY	E	4901
	EC	4902
	WC	4903
	W	4904
PR & VI		5200
	AS	5300
	GU	5400

LEGEND:

C - Central Zone
E - Eastern Zone
L - Long Island Zone (NY)
M - Mainland Zone (MA)
N - Northern Zone
NC - North-Central Zone(TX)
SH - Offshore Zone (LA)
S - Southern Zone
SC - South-Central Zone (TX)
W - Western Zone
I - Island (MA)

ANNEX D

GUIDELINES FOR GEODETIC CONTROL POINT DESIGNATIONS

A geodetic control point is a monumented or otherwise marked, survey point, established for the purpose of providing geodetic reference for mapping and charting activities and for a wide variety of engineering and scientific applications. A control point is normally identified by a number, an alphanumeric symbol, or a concise, intelligible name which is usually stamped on the disk marker. In principle, the designation by which a control point is identified should closely resemble the stamping that appears on the respective marker. However, extraneous information is frequently present which should not be included as part of the designation. In every case, the designation assigned to a control point for processing purposes must be identical to the designation that appears in the heading of the station description.

These guidelines have been established to provide consistent control point designations and facilitate automated processing of the data. Implementation of these guidelines may sometimes result in two or more control points having the same designation. In such cases it will be necessary to refer to other information in the description to completely identify the control point. Sample formats for the various designations are given in this annex.

GUIDELINES

1. A control point designation must not exceed 40 alphanumeric characters, including all imbedded blanks. When necessary, abbreviate and/or edit an existing designation to conform to this limit.

2. The year the mark was set is considered extraneous information and is not to be carried as part of a control point designation. For marks whose designations have not been altered when they were reset, the word RESET must be appended to the original designations. This also holds true for control points which have been reset more than once. In such cases the year given in the "year set" field will be used to distinguish the marks.

Monument	Stamped	Designation
USGS BM Disk	TT 8 RESET 1965	TT 8 RESET
CGS BM Disk	LAKE WASHINGTON RESET 1970	LAKE WASHINGTON RESET
CGS Tri Sta Disk	BRADY 1951	BRADY
CGS BM Disk	ONEAL 1 1954	ONEAL 1
CGS BM Disk	DE KALB 1934	DEKALB
NCGS Trav Sta Disk	MC CALL 1968	MCCALL
CGS Tri Sta Disk	DODGE 2 1969	DODGE 2
CGS Tri Sta Disk	SPIT 1953 1983	SPIT RESET
USGS Survey Disk	PRIM TRAV STA NO 185 1915	PTS 185

3. The acronym or abbreviation of the agency or organization whose name is precast or sometimes stamped in the survey marker is considered extraneous information and should not be included in the control point designation.

Monument	Stamped	Designation
FLGS BM Disk	203 RESET 1950	203 RESET
FLGS BM Disk	203 RESET 1967	203 RESET
FLGS BM Disk	203 RESET 1967 MAY	203 RESET MAY
USGS BM Disk	2903	2903
MORC Gaging Sta	GAGING STA	GAGING STA
RIRR Disk	RV 16	RV 16
USGS Chis Square		WO 23 RM=148 RM
USGS Survey Disk	WO 23 1933	WO 23
USGS Survey Disk	WO 23 1933 RESET 1962	WO 23 RESET
PP+L Survey Disk	P 11 PPL RESET 1976	P 11 RESET

4. The following special characters are the only ones allowed in a control point designation. They are the blank ( ), plus (+), minus or hyphen (-), equals (=), slash (/), and decimal point (.). When used, these special characters must not be separated from adjacent characters by any blanks. Commas and parentheses are not allowed within a designation.

4.1 Most alpha and numeric character groupings in a designation should be separated by a single blank ( ). Some exceptions are allowed, see the set of Abbreviations and Formats.

Monument	Stamped	Designation
USGS Survey Disk	TT17B	TT 17 B
USGS Survey Disk	TT-17B	TT 17 B
USGS Survey Disk	TT-1 7B	TT 1 7 B

4.2 A plus sign (+) is permitted within a designation when the control point was previously used for stationing in alignment surveys. In these cases the plus sign (+) must be immediately preceded and followed by a digit, not a blank.

Monument	Stamped	Designation
AZDT Disk	STATION 11+14	ROUTE 244 STA 11+14
Highway Disk	2623 + 00	I95 STA 2623+00

4.3 The minus or hyphen (-) is allowed only when indicating a negative elevation stamped on a mark. An elevation stamped on a mark is used as the designation only when there is no other means to identify the mark. When a minus or hyphen (-) is used, it must be the first character of the designation and must be immediately followed by a digit.

Monument	Stamped	Designation
USGS Nail (Tag)	-227.10 5-23-55	-227.10
CGS BM Disk	-193.097 F 70 1928	F 70
USGS BM Disk	ELEV -7.325 FT	-7.325

4.4 The equal sign (=) is used as a separator for control points which carry multiple stamped designations. The designations involved should be concatenated with the equal sign. The combined designation length must not exceed the 40-character limit and the designation preceding the equal sign should be the designation used by the originating agency.

Monument	Stamped		Designation
USGS Chis Square			WO 23 RM=148 RM
CADH Survey Disk	CH 1174	297+00 (A)	CH 1174=297+00 A
Unk Survey Disk	STA. NO. 3	MI. 182.5	STA 3=MI 182.5
CGS Ref Mark Disk	LEE NO 1 1932	R 13	LEE RM 1=R 13
CGS Tri Sta Disk	68.399 B 22	ATKINSON 1918	ATKINSON=B 22
USGS Cap	U 276 1942	VA 45 1917	45=U 276

NOTE: In situations where there are multiple designations that either do not appear stamped on the mark or are too long to be accommodated by the 40-character designation, the secondary designation may be given as a separate data item and carried as an alias in the appropriate field.

4.5 A slash (/) may be used to indicate a numerical fraction.

Monument	Stamped	Designation
USGLO Survey Disk	T1N R3E S35 S36 1/4 1943	T1N R3E SECS 35 36 1/4 COR

4.6 A period (.) may not appear imbedded in or adjacent to a grouping of alpha characters, but may be used as a decimal point if imbedded in (but not adjacent to) a grouping of numeric characters.

Monument	Stamped	Designation
MADPW Survey Disk	ELEV. B.M. NO. F 40	F 40
CGS Ref Mark Disk	W. BASE NO 4 1965	CHARLESTON W BASE RM 4
CADWR Survey Disk	MI. 0.9 1967	AMERICAN CANAL MI 0.9
CGS Tri Sta Disk	PALMER N.E. BASE	PALMER NE BASE
CGS BM Disk	MT. MORRIS 1941	MT MORRIS

5. Nonspecific descriptive terms are not to be treated as "double designations" and are not to be carried as aliases.

Published as	Stamped	Designation
BENCH MARK 2		2
114.3, Chis Square		114.3
C 1, Bolt		C 1

6. The characters "BM", "BENCH MARK", and "PBM", even when stamped on a disk, are not to be included in a designation unless the control point has no other stamping (e.g., BM USGS) or the characters "BM" do not represent the words "BENCH MARK."

7. The elevation stamped on the disk marker on the monument is not to be carried as a part of the respective designation. The exception is when the elevation is the only means of identifying the survey mark.

Monument	Stamped	Designation
CGS BM Disk	H 325 230.695FT	H 325
MORC Disk	140B ELEV 95.3 FT	140 B
USGS BM Disk	-9.825 FT	-9.825
BOR Survey Disk	ELEV. 101.6	101.6

8. The characters "NO" or "No.", when used as an abbreviation for the word "number", should not be included in the designation, even when they are stamped in the disk.

Monument	Stamped	Designation
CGS Ref Mark Disk	MONROE NO 1 1944	MONROE RM 1
CGS BM Disk	BENCH MARK No. 6	6

9. The designation for a reference mark disk should be formed by appending the symbols RM 1, RM 2, ..., RM 13, etc. to the name of the horizontal control point for reference marks stamped NO 1, NO 2, ..., NO 13, etc., respectively.

Monument	Stamped	Designation
CGS Ref Mark Disk	CHARLOTTE NO. 1 1945	CHARLOTTE RM 1
CGS Ref Mark Disk	BOULDER 1935 NO 6 1968	BOULDER RM 6
CGS Ref Mark Disk	CHICO 1948 NO 3 RESET 1971	CHICO RM 3 RESET

10. The designation for an azimuth mark disk is formed by appending the characters "AZ MK" to the name of the respective horizontal control point. In the case of multiple azimuth marks, the numbers "2", "3", etc. are added for azimuth marks stamped NO 2, NO 3, etc.

Monument	Stamped	Designation
CGS Az Mark Disk	CHARLOTTE 1934	CHARLOTTE AZ MK
CGS Az Mark Disk	BOULDER 1935 NO. 3	BOULDER AZ MK 3
CGS Az Mark Disk	NORWASH AZI 1932	NORWASH AZ MK
CGS Az Mark Disk	PARK AZ RESET 1965	PARK AZ MK RESET

11. A temporary bench mark (TBM) must carry the letters "TBM" as the first three characters of the designation.

Monument	Stamped	Designation
Spike		TBM 1 A
Sidewalk		TBM 14

12. The National Ocean Service (NOS) has instituted a standard system of designations for all tidal and water level stations operated by NOS. The system provides for the unique identification of all disks, staffs, etc., located at such stations (e.g., see Formats in this annex).

Tidal and water level bench mark designations must conform to standard designations adopted by the National Ocean Service. For information concerning specific tide gage bench marks, etc., communicate with:

NOAA, National Ocean Service
OPSD, User Services, N/CS44
Attn: Water Levels
1305 East-West Highway
Silver Spring, MD 20910-3281

Telephone: 1-301-713-2877 ext. 176
E-mail Address: lyles@wlnet.nos.noaa.gov
Internet Web Site: www.opsd.nos.noaa.gov

Whenever the need arises for a guideline to deal with a situation not covered herein, the user is encouraged to communicate with the following technical office in NGS:

Spatial Reference System Division, N/NGS2
National Geodetic Survey, NOAA
1315 East-West Highway
Silver Spring, MD 20910-3282

Telephone: 1-301-713-3191
E-mail Address: edm@ngs.noaa.gov
Internet Web Site: www.ngs.noaa.gov

ABBREVIATIONS

A list of standard abbreviations has been adopted for use in designating geodetic control points. These abbreviations are for terms that commonly occur in designations and are the only accepted forms of abbreviation. This list may be extended as the need arises.

Geodetic control point abbreviations	
A POINT	A PT
ACADEMY	ACAD
ADMINISTRATION	ADM
AGENCY	AGY
AGRICULTURE	AGRI
AHEAD	AHD
AIRCRAFT	ARCFT
AIRPORT	APT
AIRWAY	AWY
AIR FORCE BASE	AFB
ALLEGHENY	ALGHNY
AMBASSADOR	AMB
AMENDED	AMD
AMENDED MONUMENT (AM)	AMD MON
AMERICAN	AMER
ANGLE	ANG
ANGLE POINT (AP)	ANG PT
ANTENNA	ANT
APPALACHIAN	APLCN
APPROXIMATELY	APPROX
ASSOCIATION	ASSOC
ASTRONOMICAL	ASTRO
ASYLUM	ASY
ATLANTIC	AT
AUTHORITY	AUTH
AUXILIARY	AUX
AUXILIARY MEANDER CORNER (AMC)	AUX MDR COR
AVENUE	AVE

Notes:

1. Abbreviations listed with () are used by the Bureau of Land Management.
2. The cardinal directions (E, S, W, N, NE, SE, SW, and NW) are to be abbreviated only when they are not the first word of the designation.

Geodetic control point abbreviations (Continued)

AVIATION	AVN
AZIMUTH	AZ
BACK	BCK
BANK	BK
BANKING	BKG
BAPTIST	BAP
BATTERY	BTRY
BEACON	BCN
BEARING	BRG
BEARING OBJECT (BO)	BRG OBJ
BEARING TREE (BT)	BRG TREE
BELFRY	BFRY
BETWEEN	BET
BOULEVARD	BLVD
BOUNDARY	BDRY
BREAKWATER	BRKWTR
BRICK	BR
BROADCASTING	BCSTG
BROTHER	BRO
BROTHERS	BROS
BUILDING	BLDG
BUREAU	BUR
CAPITOL	CAP
CATHEDRAL	CATHL
CATHOLIC	CATH
CEMETERY	CEM
CENTER (C)	CEN
CENTERLINE	CL
CERAMIC	CERAM
CHEMICAL	CHEM
CHIMNEY	CHIM
CHURCH	CH
CLOCK	CLK
CLOSING CORNER (CC)	CC
COLLEGE	COLL
COMMERCE	COM
COMMERCIAL	COML
COMMISSION	COMM
COMPANY	CO
COMPRESS	COMP
CONCENTRATION	CONCN
CONCEPTION	CON
CONCRETE	CONC
CONGREGATIONAL	CONG

Geodetic control point abbreviations (Continued)

CONSOLIDATED	CONSOL
CONSTRUCTION	CONSTR
CONTINENTAL	CONTL
CONTROL	CTRL
COOPERATIVE	COOP
CORNER	COR
CORPORATION	CORP
CORRECTIONAL	CORR
COUNTRY	CTRY
COUNTY	CNTY
COURTHOUSE	CTHSE
CUPOLA	CUP
DAYBEACON	DBCN
DEFENSE	DEF
DEPARTMENT	DEPT
DISTRIBUTOR	DISTR
DIVISION	DIV
DOMESTIC	DOM
DORMITORY	DORM
DRAWBRIDGE	DBRIDGE
EAST	E
ECCENTRIC	ECC
EDUCATION	EDUC
ELECTRIC	ELEC
ELEMENTARY	ELEM
ELEVATION	ELEV
ELEVATED	ELEVD
ELEVATOR	ELEVR
ENGINEERING	ENG
ENGRAVING	ENGR
ENTRANCE	ENTR
EPISCOPAL	EPIS
EQUIPMENT	EQPT
EVANGELICAL	EVAN
EXCHANGE	EXCH
EXPERIMENTAL	EXPTL
FEDERAL	FED
FINIAL	FIN
FIRST	1ST
FLAGPOLE	FP
FLAGSTAFF	FS
FOURTH	4TH
FRONT RANGE	FRGE
FURNITURE	FURN

Geodetic control point abbreviations (Continued)

GABLE	GAB
GENERAL	GEN
GEODETIC	GEOD
GEOGRAPHIC	GEOG
GEOLOGICAL	GEOL
GOVERNMENT	GOVT
GROWERS	GROS
HARBOR	HBR
HARDWARE	HDWE
HEADQUARTERS	HQ
HEIGHTS	HTS
HIGHWAY	HWY
HISTORICAL	HIST
HOSPITAL	HOSP
HOUSE	HSE
HYDRO	HYD
IMMACULATE	IMM
IMPLEMENT	IMPL
IMPORT	IMP
INCINERATOR	INCIN
INCORPORATED	INC
INDEPENDENT	IND
INDUSTRIAL	INDL
INDUSTRY	INDY
INFIRMARY	INFIRM
INSTITUTE	INST
INSTITUTION	INSTN
INSURANCE	INS
INTERNATIONAL	INTL
INTERSTATE	INTST
INTERSECT	INT
INVESTMENT	INVT
IRRIGATION	IRRIG
ISLAND	IS
JUNCTION	JCT
LABORATORY	LAB
LANDING	LDG
LATITUDE	LAT
LATTER DAY SAINTS	LDS
LEATHER	LEA
LEFT	LT **

**The abbreviations R, T, LT, and RT must be adjacent to at least one numeric character.

Geodetic control point abbreviations (Continued)

LIGHT	LT
LIGHTHOUSE	LH
LOCAL	LCL
LOCATION	LOC
LOCATION MONUMENT (LM)	LOC MON
LOOKOUT	LO
LOOKOUT HOUSE	LOH
LOOKOUT TOWER	LOT
LONGITUDE	LON
LUMBER	LUM
LUTHERAN	LUTH
MACHINERY	MACH
MAGAZINE	MAGZ
MAGNETIC	MAG
MAINTENANCE	MAINT
MANUFACTURED	MFD
MANUFACTURING	MFG
MARK	MK
MARKET	MKT
MAST	MST
MEANDER	MDR
MEANDER CORNER (MC)	MDR COR
MERCHANDISE	MDSE
MERCANTILE	MERC
METHODIST	METH
METROPOLITAN	MET
MICROWAVE	MV
MILE or MILES	MI
MILEPOST	MP
MILITARY	MIL
MILLING	MILL
MONUMENT	MON
MOUNT	MT
MOUNTAIN	MTN
MUNICIPAL	MUN
MUSEUM	MUS
NATIONAL	NAT
NAVIGATION	NAV
NEAR	NR
NORTH	N
NORTHEAST	NE
NORTHWEST	NW
OBJECT	OBJ
OBSERVATION	OBS

Geodetic control point abbreviations (Continued)	
OBSERVATORY	OBSY
OBSTRUCTION	OBSTR
OFFICE	OFF
ORDNANCE	ORD
ORGANIZATION	ORG
ORTHODOX	ORTH
PEAK	PK
PENINSULA	PEN
PETROLEUM	PET
PINNACLE	PCLE
PLANT	PLT
POINT	PT
POINT A	PTA
POINT OF CURVE	POC
POINT OF INTERSECTION	PI
POINT OF TANGENT	POT
POLICE	POL
POWER	PWR
POWERHOUSE	PHSE
PRESBYTERIAN	PRESB
PRIMARY	PRIM
PRIMARY TRAVERSE STATION	PTS
PRINTING	PTG
PROCESS	PRCS
PRODUCING	PRODG
PRODUCT	PROD
PROPERTIES	PROP
PROTESTANT	PROT
PUBLIC	PUB
PUBLISHING	PUBG
QUARTER	QTR
RADIO	RAD
RAILROAD	RR
RAILWAY	RWY
RANGE	RGE
RANGE (Township)	R **
REAR RANGE	RRGE
REFERENCE	REF
REFERENCE MARK	RM
REFERENCE MONUMENT (RM)	REF MON
REFERENCE POINT	RP

**The abbreviations R, T, LT, and RT must be adjacent to at least one numeric character.

Geodetic control point abbreviations (Continued)

REFINING	REFG
REFORMED	REFM
REFRIGERATING	REFRIG
RESET	RST
RIGHT	RT **
RIGHT OF WAY	ROW
ROAD	RD
ROMAN	ROM
ROUTE	RTE
RUNWAY	RNWY
SAINT	ST
SANITARY	SANIT
SANITORIUM	SAN
SAVINGS	SVGS
SCHOOL	SCH
SCHOOLHOUSE	SCHSE
SCIENTIFIC	SCI
SECOND	2ND
SECTION	SEC
SECTIONS	SECS
SEMINARY	SEM
SERVICE	SERV
SOCIETY	SOC
SOUTH	S
SOUTHEAST	SE
SOUTHWEST	SW
SPECIAL	SPL
SPECIAL MEANDER CORNER (SMC)	SPL MDR COR
SPIRE	SP
SQUARE	SQ
STACK	STK
STANDARD	STD
STANDARD CORNER (SC)	SC
STANDPIPE	SPIPE
STATION	STA
STEEPLE	STPE
STORAGE	STGE
STREET	STR
SUBURBAN	SUBR
SUPERINTENDENT	SUPT
TANK	TK

**The abbreviations R, T, LT, and RT must be adjacent to at least one numeric character.

Geodetic control point abbreviations (Continued)

TANGENT	TAN
TANGENT OFFSET	TOS
TECHNICAL	TECH
TELEGRAPH	TELG
TELEPHONE	TEL
TELEVISION	TV
TEMP POINT A	TP A
TERMINAL	TERM
TERRITORY	TERR
THEOLOGICAL	THEO
THIRD	3RD
TOWER	TWR
TOWNSHIP	TWP
TOWNSHIP (Tier)	T **
TRACT	TR
TRANSCONTINENTAL	TRANSCON
TRANSMISSION	TRANSM
TRANSPORTATION	TRANSP
TRAVERSE	TRAV
TRAVERSE STATION	TS
TRIANGLE	TRI
TURNPIKE	TPK
UNITARIAN	UNIT
UNIVERSITY	UNIV
VACUUM	VAC
VERTEX	VTX
VILLAGE	VIL
WATER	WT
WEST	W
WAREHOUSE	WHSE
WINDMILL	WMILL
WITNESS CORNER (WC)	WC
WITNESS POST (WP), wood	WP
WITNESS POST, metal	MWP
WITNESS POST, fiberglass	FWP

**The abbreviations R, T, LT, and RT must be adjacent to at least one numeric character.

FORMATS

Only NGS employees and agents may set brass disks and aluminum flanges precast with NGS logo. Such marks must be stamped with designations supplied by the agency. Each geodetic control point designation should be unique among all the designations located within a defined region.

Format	Page
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Highways and Roads	D-25
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FORMAT: NAME SPECIAL

1. NAME

   A. The following method is generally used for naming vertical control points (bench marks). The first mark established in a state is designated "A", then "B" and so on through the alphabet, except the letters "I" and "O" which are not used because they are too easily confused with the numbers "1" and "O". The next series of marks is identified as "A 1", "B 1", etc.; then "A 2", "B 2", etc., and so on through the alphabet. In some cases, more than one letter is used to distinguish between bench marks that have accidentally been given the same name in the same state.

   B. The following method is generally used for naming a horizontal control point (triangulation or traverse). The name should serve not only to identify the station but to suggest the local geographic location or feature. The name should be used only once within a county and preferably a given state. Therefore, use sufficient variety to avoid duplication. A short name is desirable, but if a longer name is required to properly serve the purpose, it should be used. In those cases where a well known geographical feature in the vicinity is used, or the name of a local landowner, the name should be spelled correctly.

2. SPECIAL USE

   A. These terms are used with vertical control points to distinguish between names used more than once in a state or to indicate disturbance of the original bench mark (e.g., "RESET").

   B. These terms are used with horizontal control points to explain a local use or disturbance to the original mark or its designation.

Examples:

Geodetic control points

NAME		SPECIAL
Station	Number	Use
A		
L	690	
L	690	RESET
YY	1150	
C	1244	X
LEON		
LEON		ECC
LEON		RESET
LEON	RM 1	
LEON	RM 2	
LEON	AZ MK	
LEON	AZ MK	RESET
LEON	AZ MK	PTA
LEON	AZ MK 2	
LEON 2		
LEON 2	RM 3	
LEON 2	RM 4	
LEON 2	AZ MK	
LEON 2	AZ MK 2	

Tide station bench marks

FORMAT: LOCATION OBJECT SPECIAL

1. LOCATION Code and Station

   A. The location has two parts, the first part, the CODE, is a 3-digit State code given for each geographical region.
   B. The second part of the location, the STATION NUMBER, is an unique 4-digit number assigned to a particular tide station within a given geographical area.

2. OBJECT Identification

   A. The MARK USE gives information on the nature of the object which was used.
   B. The PUBLICATION NAME is used to give the proper identification of the object. In most cases, this field should be based on the stamping. If there is no stamping, use the name given in the tidal publication. In either case, this field is subject to the guidelines given in this Annex.

3. SPECIAL Use

   This term is used to explain a local use or disturbance to the original mark.

   NOTE: If other types of marks are used in tidal surveys, see other format rules for their primary designations; and add aliases according to the following examples:

Mark type	DS (Triangulation Station Mark)
Stamping	BREACH 1963
Primary designation	BREACH
Alias	866 5552 TIDAL

Mark type	DB (Bench Mark Disk)
Stamping	V 163 RESET 1984
Primary designation	V 163 RESET
Alias	872 9871 TIDAL

Examples

Tide station bench marks set before or about 1976

LOCATION		OBJECT		SPECIAL
Code State	Station No.	Mark use	Identification Publication name	Use
866	1684	TIDAL	HB 1	
857	4680	TIDAL	BASIC	
872	0030	TIDAL	37	RESET
944	0886	TIDAL	USE 5	

Tide station bench marks set after about 1976

LOCATION		OBJECT		SPECIAL
Code State	Station No.	Identification Publication name	Mark use	Use
872	0051	D	TIDAL	
872	9554	C	TIDAL	RESET

Staffs or electric tape gage (ETG) reading marks
at tide or water-level stations

FORMAT: TEMPORAL LOCATION OBJECT SPECIAL

1. TEMPORAL Reference

   The Temporal Reference is identified by setting the term "TBM" in front of the location.

2. LOCATION Code and Station

   A. The location has two parts, the first, the CODE, is either a 3-digit STATE number code for a State or a 3-digit CUTTER code for defining a part of a lake or channel.
   B. The second part of the location, the STATION NUMBER, is an unique 4-digit number assigned to a particular tide or water level station within a given geographical area.

3. OBJECT Identification

   The Object Identification gives information on the nature of the object that was used.

4. SPECIAL Use

   These terms are used to indicate the graduation of the tide or water level staff on which the level rod was placed.

Examples

Staffs located at tide stations

TEMPORAL	LOCATION		OBJECT	SPECIAL
Reference	Code State	Station No.	Identification	Use
TBM	872	2029	STAFF	6 FT

Electric (or "zero electric") tape gage reading marks at tide stations

TEMPORAL	LOCATION		OBJECT	SPECIAL
Reference	Code State	Station No.	Identification	Use
TBM	872	9678	ETG READ MK	

Staffs located at water level stations

TEMPORAL	LOCATION		OBJECT	SPECIAL
Reference	Code Cutter	Station No.	Identification	Use
TBM	906	3000	STAFF	6 FT

Electric tape gage (ETG) reading marks at water level stations

TEMPORAL	LOCATION		OBJECT	SPECIAL
Reference	Code Cutter	Station No.	Identification	Use
TBM	907	5099	ETG READ MK	

Water level station bench marks

FORMAT:	LOCATION	OBJECT	SPECIAL

1. LOCATION Code and Station

   A. The first part of the location is the 3-digit code for defining a part of a lake or channel within the CUTTER Code System.
   B. The second part of the location, the STATION NUMBER, is a unique 4-digit number assigned to the water level station within a given geographical area.

2. OBJECT Identification

   In most cases, this field should be based on the stamping. If there is no stamping, use the name given in the water level publication. In either case, this field is subject to the guidelines given in this annex.

3. SPECIAL Use

   These character strings are used to explain some local use or disturbance to the original mark.

   NOTE: If other types of marks are used in water level surveys, see other format rules for their primary designation and add an alias according to the following example:

Mark type	F	(flange-encased rod)
Stamping	C 234 1980	(on logo cap)
Primary designation	C 234	
Alias	906 3087	

Examples

Water level station bench marks set before or about 1976

LOCATION		OBJECT	SPECIAL
Code Cutter	Station No	Identification	Use
907	5098	ROAD A	
907	5098	ROAD A	RESET

Water level station bench marks set after about 1976

LOCATION		OBJECT	SPECIAL
Code Cutter	Station No.	Identification	Use
907	5085	F	
907	5085	F	RESET

Airport runways

FORMAT: ALIGNMENT OBJECT LOCATION SPECIAL

1. ALIGNMENT Survey Name

   Use the proper NAME of the town, city, or a geographic location within the area for the airport.

2. OBJECT Identification

   Enter the type of alignment object, in this case it is the airport RUNWAY.

3. LOCATION Station (Runway Number) and Tangent Offset (TOS)

   A. The location has two parts, the first part is called the runway number and should be a 2-digit numerical value. These two digits are taken from the first two digits of the 3-digit runway (measured from north) azimuth, i.e., 01, 13, 22, or 34 which were taken from the azimuths of 010, 130, 220, and 340 respectively.

   B. The second part of the location, the tangent offset (TOS), is the location of the control point in question with respect to the center of the alignment, that is, the distance (in meters/feet) either left or right.

4. SPECIAL Use

   Terms such as A PT, ECC, HUB, PTA, RESET, and TP A are used to explain a local use or disturbance to the original mark.

Examples

Airport runways

ALIGNMENT	OBJECT	LOCATION		SPECIAL
Survey name	Identification	Station	TOS	Use
KENNEWICK AIRPORT				
KENNEWICK AIRPORT				ECC
KENNEWICK AIRPORT				RESET
KENNEWICK APT AZ MK				
KENNEWICK APT	RUNWAY	00	OFFSET	HUB
KENNEWICK APT	RUNWAY	36	CL	
KENNEWICK APT	RNWY	02	CL	
KENNEWICK APT	RNWY	20	CL	

Political boundaries

FORMAT: ALIGNMENT OBJECT DESIGNATE POLITICAL SPECIAL

1. ALIGNMENT Survey

   The term BOUNDARY is used when two or more participants are in common or adjacent to an alignment.

2. OBJECT Identification

   Enter the type of alignment object, such as name, station, miles, mileposts, monuments, reference points, etc.

3. DESIGNATE Reference

   The designate reference is used to identify the unique number, letters, or symbols that describe the control point.

4. POLITICAL Participants

   A. All participants in common or adjacent to the alignment boundary are listed in alphabetical order.
   B. The political participants to be selected and entered first will be by the following order: international, federal, reservations, state, county, municipal, and private.
   C. The selection order will provide the correct entries for the country/state and county fields used within the NGS data base.

5. SPECIAL Use

   Terms such as A PT, ECC, HUB, PTA, RESET, and TP A are used to explain a local use or disturbance to the original mark.

Examples

Political boundaries

ALIGNMENT Survey	OBJECT Identification	DESIGNATE Reference	POLITICAL Participants	SPECIAL Use
BOUNDARY	MONUMENT	84 A	MX US	RESET
BOUNDARY	MILEPOST	360	ND SD	
BOUNDARY	TRAVERSE STATION	110 A	CD US	ECC
BOUNDARY	ARC STONE	14	DE PA	RESET
BOUNDARY	CORNER STONE	2	MD PA	
BOUNDARY	TANGENT STONE	1	DE MD	
BOUNDARY	INTERSECT STONE	OFFSET	DE PA	
BOUNDARY	POINT	24	CD US	
BOUNDARY	REFERENCE POINT	22	AZ CA	

FORMAT: ALIGNMENT OBJECT LOCATION SPECIAL

1. ALIGNMENT Survey Name

   A. Use the term Ixxx for all Interstate highways.
   B. Use the term HIGHWAY for all Federal highways.
   C. Use the term ROUTE for all State highways.
   D. Use the term ROAD for all county roads.
   E. Use the municipality name for all local streets, avenues, boulevards, pikes, roads, etc.

2. OBJECT Identification

   A. Enter the type of alignment object, such as the name and station, miles, mileposts, monuments, reference points, etc.
   B. Or enter the proper name of the alignment, such as the name of the city street.

3. LOCATION Station and Tangent Offset

   A. The location uses two parts, the first part is called the stationing. This part should be, for most cases, a numeric value.
   B. The second part of the location, the tangent offset (TOS), is the location of the point in question with respect to the center of the alignment, that is, the distance (in meters/feet) either left or right.

4. SPECIAL Use

   Terms such as A PT, ECC, HUB, PTA, RESET, and TP A are used to explain a local use or disturbance to the original mark.

Examples
Highways and roads

ALIGNMENT	OBJECT	LOCATION		SPECIAL
Survey name	Identification	Station	TOS	Use
I495	MILEPOST	99.387		ECC
HIGHWAY 50	STATION	1234+00	CL	
ROUTE 355	STATION MARK	233+16	50LT	
ROUTE 193	REFERENCE POINT	21+00	POC	
ROAD 2786	MILEPOST	37.3		RESET
ROCKVILLE	MAPLE AVE STA	1+32	39RT	
ROCKVILLE	MAPLE AVE STA	2+50	POT	
PASCO	MAIN STREET	PI 9		

FORMAT: ALIGNMENT OBJECT LOCATION SPECIAL

1. ALIGNMENT Survey

   A. The terms RAILROAD or RAILWAY for alignments which follow these right-of-ways.
   B. Use the characters CANAL or REACH for those man made waterways.
   C. Use the characters RIVER for all natural waterways.

2. OBJECT Identification

   Enter the type of alignment object, such as name, station, miles, mileposts, monuments, reference points, etc.

3. LOCATION Station and Tangent Offset

   A. The location uses two parts, the first part is called the stationing. This part should be, for most cases, a numeric value.

   B. The second part of the location, the tangent offset (TOS), is the location of the point in question with respect to the center of the alignment, that is, the distance (in meters/feet) either left or right.

4. SPECIAL Use

   Terms such as A PT, ECC, HUB, PTA, RESET, and TP A are used to explain a local use or disturbance to the original mark.

Examples

Railroads, canals and rivers

ALIGNMENT	OBJECT	LOCATION		SPECIAL
Survey	Identification	Station	TOS	Use
RAILROAD	MILEPOST	347.8	CL	RESET
RAILWAY	MILEPOST	216.455	OFFSET	
REACH	1	22+00	400LT	ECC
REACH	1	PI 2		
REACH	3	295+00	400LT	
RIVER	SNAKE MILEPOST	37.3		

Landmarks

FORMAT: LOCATION OWNERSHIP OBJECT SPECIAL

1. LOCATION

   A. The general area in which the landmark is located should be used, such as the nearest city, town, or local geographic area.
   B. However, some landmarks by the nature of their name alone will be enough to give a general location, e.g. STATUE OF LIBERTY (New York), SEARS TOWER (Chicago), and SEATTLE SPACE NEEDLE (Seattle).

2. OWNERSHIP

   A. The ownership should be the proper name of the existing owner at the time the landmark was positioned. Later recovery information will reflect the changes of ownership.
   B. If the ownership is a political group, such as a state or county, do not include the name of the state or county.

3. OBJECT Identification
   For a landmark, enter a general name in order to identify it.

4. SPECIAL Target
   The special target is used to uniquely identify the exact object sighted as the landmark.

Examples
Landmarks

LOCATION	OWNERSHIP	OBJECT Identification	SPECIAL Target
ASHLAND	MUNICIPAL	AIRPORT	BEACON
BETHESDA	GREEK ORTHODOX	CHURCH	CROSS
CARSON CITY	STATE POLICE	RADIO STATION	MAST
FRANKLIN	COUNTY	HOSPITAL	FLAGPOLE
KEY WEST	FORT MONROE	BATTERY	RED LIGHT
LAS VEGAS		TV STATION KLAS	MAST
LOVELOCK		RADIO STATION KOB 893	MAST
NEW YORK	PORT AUTHORITY	BUILDING	FLAGPOLE
PASCO	COUNTY	COURTHOUSE	DOME
POTOMAC	ST MARKS CATHOLIC	CHURCH	SPIRE
ROCKVILLE	HUGHES AIRCRAFT	BUILDING	APEX
ROCKVILLE	MUNICIPAL	GAS TANK	FINIAL
ROCKVILLE	MUNICIPAL	WATER TANK	BALL
ROCKVILLE	MUNICIPAL	STANDPIPE	FINIAL
SALEM	1ST METHODIST	CHURCH	WEST SPIRE
SALEM	STATE	HOSPITAL CLOCK	APEX
WINNEMUCCA		RADIO STATION KWNA	MAST

Township and range control point information

FORMAT: TOWNSHIP RANGE SECTION LOCATION

Department of Interior, Bureau of Land Management disks are always marked by stamping them so as to be read looking north while standing on the south side. This relationship gives the viewer a pictorial or graphical representation of the physical relationship of the existing subdivision of the land under survey.

The south and east boundaries of each township, for the most part, are the controlling sides, whereas north and west township boundaries will close onto the controlling standard parallel to the north and the guide meridian to the west of it respectively.

1. TOWNSHIP

   A. One Township #
      Indicate the Township containing the identified survey monument.
   B. Two Townships ## (read from south to north)
      (1) List southernmost FIRST (one with lowest latitude)
      (2) List northernmost SECOND (one with higher latitude)

2. RANGE

   A. One Range #
      Indicate the Range containing the identified survey monument.
   B. Two Ranges ## (read from west to east)
      (1) List Range on the left FIRST (western most)
      (2) List Range on the right SECOND (eastern most)

3. SECTION

   A. Arrange and list all sections to be included, in a string of increasing section numbers.
   B. For Township surveys which are incomplete, show the identification (see part 4) as a Cardinal Corner of the "One" lowest section where the subdivision survey has been completed.

4. LOCATION - Identification of a Subdivision Survey Point

A.	Standard Corner	S C
B.	Closing Corner	C C
C.	Meander Corner	M C
D.	Quarter-Section Corner	1/4 COR
E.	Location Monument	L M
F.	Angle Point	A P
G.	Witness Corner	W C
H.	Cardinal Corner	***
I.	Identification as Found	NIR S180 MP31

***Use Lowest Section Number Completed.

```
  |    |    |    |    |   |                            |
  |  4TH STD PARALLEL NORTH (96 miles)                 |
  + -- + -- + -- + -- + -- +---------------------------+------
N |    |    |    |    |    |      |      |      |      |
O |    F    S    3    4    5|      |      |      | T16N |6
R |    I    E    R    T    T|      |      |      | R24E |T
T |    R    C    D    H    H|      |      |      |      |H
H |    S    O              |------|------|------|------|
  |    T    N    |    |    G|      |      |      |      |G
  |         D    |    |    U|      |      |      | T15N |U
  |    |         |    |    I|      |      |      | R24E |I
P |    |    |    |    |    D|      |      |      |      |D
R |                        E|------|------+******+------|E
I |                         |      |      *      *      |
N |                        M|      |      * T14N * T14N |M
C |                        E|      |      * R23E * R24E |E
I |                        R|      |      *      *      |R
P |                        I|------|------+******+------|I
A |                        D|      |      |      |      |D
L |                        I| T13N | T13N | T13N | T13N |I
  |    |    |    |    |    A| R21E | R22E | R23E | R24E |A
  |    |    |    |    |    N|      |      |      |      |N
M + -- + -- + -- + -- + -- +---------------------------+------
E |  3RD STD PARALLEL NORTH (72 miles)                 |
R |                        |                           |
I |
D + -- + -- + --
I |  SECOND STD PARALLEL NORTH (48 miles)
A |
N |
  + -- + -- + --
  |  FIRST STD PARALLEL NORTH (24 miles)
  |
  |
  + -- + -- BASE LINE
  |\
S | \ (INITIAL POINT)
O |
U |
T |  FIRST STD PARALLEL SOUTH (24 miles)
H + -- + -- + --
  |
```

Figure D.1 - Layout of Standard Parallels and Guide Meridians.

```
T15N R22E |                T15N R23E                | T15N R24E
    36    |  31  |  32  |  33  |  34  |  35  |  36  |    3
          |      |      |      |      |      |      |
--------- +******+******+******+******+******+******+ ----------
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
     1    *   6  |   5  |   4  |   3  |   2  |   1  *    6
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
       -- +------+------+------+------+------+------+ --
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
    12    *   7  |   8  |   9  |  10  |  11  |  12  *    7
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
       -- +------+------+------+------+------+------+ --
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
    13    *  18  |  17  |  16  |  15  |  14  |  13  *   18
          *      |      |             |      |      *
T14N      *      |      |   T14N      |      |      *      T14N
R22E   -- +------+------+--- R23E ----+------+------+ --   R24E
          *      |      |             |      |      *
          *      |      |      |      |      |      *
    24    *  19  |  20  |  21  |  22  |  23  |  24  *   19
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
       -- +------+------+------+------+------+------+ --
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
    25    *  30  |  29  |  28  |  27  |  26  |  25  *   30
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
       -- +------+------+------+------+------+------+ --
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
    36    *  31  |  32  |  33  |  34  |  35  |  36  *   31
          *      |      |      |      |      |      *
          *      |      |      |      |      |      *
----------+******+******+******+******+******+******+-----------
          |      |      |      |      |       |     |
     1    |   6      5      4      3      2      1  |    6
T13N R22E |                T13N R23E                | T13N R24E
```

Figure D.2 - T14N R23E SECS (1 - 36) as shown in Figure D.1.

```
                     T14N R23E

    SEC 33  |        SEC 34         |  SEC 35
            |                       |
  --------(A)---------(B)---------(C)--------
            |                       |
    SEC 4   |        SEC 3          |  SEC 2

                     T13N R23E


                     T13N R23E

    SEC 33  |        SEC 34         |  SEC 35
            |                       |
    -----+-(D)---------(E)-------+-(F)---- 3RD STD PARALLEL NORTH
        (X)                     (Y)
 SEC 4   |        SEC 3          |  SEC 2

                  T12N R23E
```

Figure D.3 - Designations for East/West Boundary Corners.

Examples

	TOWNSHIP	RANGE	SECTION	LOCATION
A	T13 14N	R23E	SECS 3 4 33 34	
B	T13 14N	R23E	SECS 3 34	1/4 COR
C	T13 14N	R23E	SECS 2 3 34 35	
D	T13N	R23E	SECS 33 34	SC
or D	T13N	R23E	SEC 33	SE COR
E	T13N	R23E	SEC 34	1/4 COR
F	T13N	R23E	SECS 34 35	SC
or F	T13N	R23E	SEC 34	SE COR
X	T12N	R23E	SECS 3 4	CC
Y	T12N	R23E	SECS 2 3	CC

```
                  T17N R24E            |            T17N R25SE
                                 S 36  |  S 31
--- 4TH STD PARALLEL NORTH  ------+---(L)----
                                 (Y)
                             S 1  |  S 6
                               --(K)-
                             S 12 |  S 7
                               --(J)-
             T16N R24E            |            T16N R25E
                         --------(I)--------
             T15N R24E            |            T15N R25E
                         --------(H)--------
             T14N R24E            |            T14N R25E
                         --------(G)--------
                             S 1  |  S 6
                               --(F)-
                             S 12 |  S 7
                               --(E)-
                             S 13 |  S 18
             T13N R24E         --(D)-          T13N R25E
                             S 24 |  S 19
                               --(C)-
                             S 25 |  S 30
                               --(B)-
                             S 36 |  S 31
--- 3RD STD PARALLEL NORTH ---+--(A)--------
                             (X)
                         S 1  |  S 6
             T12N R24E      -(W)-              T12N R25E
                              |
```

Figure D-4 - Designations for North/South Boundary Corners.

Examples

	TOWNSHIP	RANGE	SECTION	LOCATION
W	T12N	R24 25E	SECS 1 6 7 12	
X	T12N	R24 25E	SECS 1 6	CC
A	T13N	R24 25E	SECS 31 36	SC
B	T13N	R24 25E	SECS 25 30 31 36	
C	T13N	R24 25E	SECS 19 24 25 30	
D	T13N	R24 25E	SECS 13 18 19 24	
E	T13N	R24 25E	SECS 7 12 13 18	
F	T13N	R24 25E	SECS 1 6 7 12	
G	T13 14N	R24 25E	SECS 1 6 31 36	
H	T14 15N	R24 25E	SECS 1 6 31 36	
I	T15 16N	R24 25E	SECS 1 6 31 36	
J	T16N	R24 25E	SECS 7 12 13 18	
K	T16N	R24 25E	SECS 1 6 7 12	
Y	T16N	R24 25E	SECS 1 6	CC
L	T17N	R24 25E	SECS 31 36	SC

ANNEX E

STATION ORDER-AND-TYPE (OT) CODES

This annex contains lists of the various types of horizontal control points with the corresponding two-character Order-and-Type (OT) Codes. Effective July 1, 2012, the order codes were replaced by horizontal network and local accuracies for nearly all stations with GPS-derived positions in the NGS Integrated Data Base. The network and local accuracies are recorded in the *91* and *92* records, respectively, as described in Chapter 2 of the Bluebook. Network and local accuracies have been determined for all GPS projects loaded into the NGS Integrated Data Base since the 2011 national adjustment.

The horizontal order codes still apply to all horizontal control determined using classical (optical) methods, as well as a small number of GPS stations not included in the 2007 or 2011 national adjustments. Note that effective January 1, 2011, NGS no longer accepts classical data for determining horizontal control, as described in "Data Submission Policy" Addendum V.

For control stations where it is used, the horizontal order code (i.e., first character of the OT Code) indicates the general positional accuracy of the station. This accuracy is relative to the main-scheme network of which the horizontal control point in question is a part or to which it is connected. It also indicates whether the horizontal control point is permanently marked and recoverable (e.g., a monumented station or a landmark) or not permanently marked and hence nonrecoverable (e.g., an auxiliary point). The type code (i.e., second character of the OT Code) still applies to all horizontal control to identify the surveying method by which the station position was determined. Use of the OT Codes is explained in Chapter 2, pages 2-35 thru 2-38, in accordance with the following classification:

ORDER CODES OF RECOVERABLE POINTS:

- A - Order A Interferometric Positioning
- B - Order B Interferometric Positioning
- 0 - Trans-Continental Traverse (TCT)
- 1 - lst-Order Survey Scheme
- 2 - 2nd-Order (Class I and Class II) Survey Scheme
- 3 - 3rd-Order (Class I and Class II) Survey Scheme
- 4 - Lower-Than-3rd-Order Survey Scheme and Supplemental Unmonumented Recoverable Landmarks (see p. E-4)

ORDER CODES OF NONRECOVERABLE POINTS:

- 5 - lst-Order Survey Scheme
- 6 - 2nd-Order (Class I and Class II) Survey Scheme
- 7 - 3rd-Order (Class I and Class II) Survey Scheme
- 8 - Lower-Than-3rd-Order Survey Scheme

The second code (i.e., the "type code") of the OT Code indicates the type of the (primary) surveying method by which the horizontal control point is positioned. It also shows whether the horizontal control point in question is a main-scheme station (i.e., one which is essential to the survey scheme) or a supplemental station (i.e., one which is incidental to the survey scheme):

TYPE CODES OF MAIN-SCHEME STATIONS:

- 1 - Positioned Primarily by Triangulation (or by Intersection)
- 2 - Positioned Primarily by Trilateration
- 3 - Positioned Primarily by Traverse
- A - Positioned Primarily by Interferometric Satellite Relative Positioning

TYPE CODES OF SUPPLEMENTAL STATIONS:

4 - Positioned Primarily by Triangulation
5 - Positioned Primarily by Trilateration
6 - Positioned Primarily by Traverse
7 - Positioned by Intersection (Note: 1 if Main-Scheme Station)
8 - Positioned by Resection
B - Positioned Primarily by Interferometric Satellite Relative Positioning

ORDER-AND-TYPE (OT) CODES OF RECOVERABLE HORIZONTAL CONTROL POINTS - monumented (or otherwise permanently marked) stations, published as indicated.

SURVEY PROCEDURES	STATION TYPE	OT	PUBLISHED
*****************	************	**	*********
MONUMENTED STATIONS POSITIONED BY GPS			
GPS Procedures	Main-Scheme	AA	AA-Order
GPS Procedures	Main-Scheme	BA	B-Order
GPS Procedures	Supplemental	BB	B-Order
STATIONS OF THE TRANS-CONTINENTAL TRAVERSE (TCT)			
TCT Procedures	Main-Scheme *	03	lst-Order
TCT Procedures	Supplemental **	06	lst-Order
MONUMENTED STATIONS POSITIONED PRIMARILY BY TRIANGULATION			
lst-Order	Main-Scheme	11	lst-Order
lst-Order	Supplemental	14	2nd-Order
2nd-Order (Class I or II)	Main-Scheme	21	2nd-Order
2nd-Order (Class I or II)	Supplemental	24	3rd-Order
3rd-Order (Class I or II)	Al Stations	31	3rd-Order
Lower-Than-3rd-Order	All Stations	41	Low-Order
MONUMENTED STATIONS POSITIONED PRIMARILY BY TRILATERATION			
lst-Order	Main-Scheme	12	lst-Order
lst-Order	Supplemental	15	2nd-Order
2nd-Order (Class I or II)	Main-Scheme	22	2nd-Order
2nd-Order (Class I or II)	Supplemental	25	2nd-Order
3rd-Order (Class I or II)	All Stations	32	3rd-Order
Lower-Than-3rd-Order	All Stations	42	Low-Order
MONUMENTED STATIONS POSITIONED PRIMARILY BY TRAVERSE			
lst-Order	Main-Scheme	13	lst-Order
lst-Order	Supplemental	16	2nd-Order
2nd-Order (Class I or II)	Main-Scheme	23	2nd-Order
2nd-Order (Class I or II)	Supplemental	26	2nd-Order
3rd-Order (Class I or II)	All Stations	33	3rd-Order
Lower-Than-3rd-Order	All Stations	43	Low-Order

* Main-Scheme Station - one which is essential to the survey scheme.
** Supplemental Station - one which is incidental to the survey scheme.

SURVEY PROCEDURES	STATION TYPE	OT	PUBLISHED
**************************	************	**	*********

MONUMENTED STATIONS POSITIONED BY INTERSECTION

lst-Order	Main-Scheme	11	lst-Order
lst-Order	Supplemental	17	2nd-Order
2nd-Order (Class I or II)	Main-Scheme	21	2nd-Order
2nd-Order (Class I or II)	Supplemental	27	3rd-Order
3rd-Order (Class I or II)	All Stations	37	3rd-Order
Lower-Than-3rd-Order	All Stations	47	Low-Order

MONUMENTED STATIONS POSITIONED BY RESECTION

lst-Order	All Stations	18	2nd-Order
2nd-Order (Class I or II)	All Stations	28	2nd-Order
3rd-Order (Class I or II)	All Stations	38	3rd-Order
Lower-Than-3rd-Order	All Stations	48	Low-Order

ORDER-AND-TYPE (OT) CODES OF NONRECOVERABLE HORIZONTAL CONTROL POINTS -temporary or auxilliary points, not permanently marked, which must be carried in the files for network integrity purposes. These horizontal control points will not be published.

SURVEY PROCEDURES	STATION TYPE	OT
******************	************	**

STATIONS OF THE TRANS-CONTINENTAL TRAVERSE (TCT) - must be monumented.

UNMARKED STATIONS POSITIONED PRIMARILY BY TRIANGULATION

lst-Order	Main-Scheme*	51
lst-Order	Supplemental**	54
2nd-Order (Class I or II)	Main-Scheme	61
2nd-Order (Class I or II)	Supplemental	64
3rd-Order (Class I or II)	All Stations	71
Lower-Than-3rd-Order	All Stations	81

UNMARKED STATIONS POSITIONED PRIMARILY BY TRILATERATION

1st-Order	Main-Scheme	52
1st-Order	Supplemental	55
2nd-Order (Class I or II)	Main-Scheme	62
2nd-Order (Class I or II)	Supplemental	65
3rd-Order (Class I or II)	All Stations	72
Lower-Than-3rd-Order	All Stations	82

---

* Main-Scheme Station - one which is essential to the survey scheme.

** Supplemental Station - one which is incidental to the survey scheme.

SURVEY PROCEDURES	STATION TYPE	OT
***************	********** **	**
UNMARKED STATIONS POSITIONED PRIMARILY BY TRAVERSE		
1st-Order	Main-Scheme	53
1st-Order	Supplemental	56
2nd-Order (Class I or II)	Main-Scheme	63
2nd-Order (Class I or II)	Supplemental	66
3rd-Order (Class I or II)	All Stations	73
Lower-Than-3rd-Order	All Stations	83
UNMARKED STATIONS POSITIONED BY INTERSECTION		
lst-Order	Main-Scheme	51
lst-Order	Supplemental	57
2nd-Order (Class I or II)	Main-Scheme	61
2nd-Order (Class I or II)	Supplemental	67
3rd-Order (Class I or II)	All Stations	77
Lower-Than-3rd-Order	All Stations	87
UNMARKED STATIONS POSITIONED BY RESECTION		
lst-Order	All Stations	58
2nd-Order (Class I or II)	All Stations	68
3rd-Order (Class I or II)	All Stations	78
Lower-Than-3rd-Order	All Stations	88

ORDER-AND-TYPE (OT) CODES OF UNMONUMENTED RECOVERABLE LANDMARKS - normally positioned as supplemental low-accuracy control points, possibly used as main-scheme triangulation stations (e.g., a well-defined church spire used as the unoccupied center of a central-point figure in a triangulation network), published as indicated.

SURVEY PROCEDURES	STATION TYPE	OT	PUBLISHED
*****************	************	**	*********
LANDMARKS USED AS MAIN-SCHEME TRIANGULATION STATIONS			
lst-Order	Main-Scheme	11	lst-Order
2nd-Order (Class I or II)	Main-Scheme	21	2nd-Order
3rd-Order (Class I or II)	Main-Scheme	31	3rd-Order
Lower-Than-3rd-Order	Main-Scheme	41	Low-Order
LANDMARKS POSITIONED AS SUPPLEMENTAL CONTROL POINTS			
Any-Order Traverse	Supplemental	43	Low-Order
Any-Order Intersection	Supplemental	47	Low-Order
Any-Order Resection	Supplemental	48	Low-Order

ANNEX F

NGS SURVEY EQUIPMENT CODES

000-099 - Gravity Instruments and Satellite Systems
100-199 - Theodolites and Transits
200-299 - Leveling Instruments
300-399 - Leveling Rods and Staffs
400-499 - Steel and Invar Tapes
500-599 - Lightwave Distance-Measuring Equipment
600-699 - Infrared Distance-Measuring Equipment
700-799 - Microwave Distance-Measuring Equipment
800-899 - Total Station-Measuring Equipment
900-999 - Other Miscellaneous Surveying Equipment

The purpose of the National Geodetic Survey (NGS) Survey Equipment Code is to provide a three-digit identifier for each item of survey equipment commonly used in connection with horizontal and vertical control surveys in the United States. The code has been devised in such a manner that the first digit of the three-digit identifier would indicate a specific category of survey equipment. Accordingly, there are ten broad survey equipment categories, the first of which (000-099) is reserved for gravity instruments and satellite systems, and the last (900-999) is reserved for miscellaneous survey equipment which does not fit into any of the specific categories. The ten survey equipment categories are listed above.

Within each category, specific items and/or classes of survey equipment have been grouped into subcategories and assigned unique three-digit code numbers. The grouping of survey equipment into subcategories is intended to reflect the level of accuracy attained in common usage of the specific items or classes of survey equipment in question and not necessarily their intrinsic or potential accuracy. In each category and subcategory, a code is provided for items of survey equipment which do not appear among the items listed or which are not specifically identified. The respective lists of survey equipment are not all-inclusive, and series of numbers have been skipped in each category and/or subcategory to allow for additions.

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
****	***********	************************

000-099 - GRAVITY INSTRUMENTS AND SATELLITE SYSTEMS

000	Unspecified	Unknown Instrument or System

001-009 - Reserved for Absolute Gravity Devices

010-029 - Gravimeters

010	Unspecified	Gravimeter
011	Frost	Frost Gravimeter
012	North American	North American Gravimeter
013	LaCoste-Romberg	Early Models
014	LaCoste-Romberg	G-Meter
015	LaCoste-Romberg	D-Meter
016	Worden	Unspecified
017	Worden	Uncompensated Model
018	Worden	Temperature-Compensated Model
019	Scintrex	CG-2

030-049 - Doppler Satellite Tracking Systems

030	Unspecified	Doppler Satellite Tracking System
031	Magnavox	Geoceiver or Geoceiver II
032	JMR	JMR-1
033	ITT	ITT 5500
034	Magnavox	MX-702A
035	APL	Tranet
036	Canadian	Marconi CMA 722A
037	Canadian	Marconi CMA 722B
038	Magnavox	MX-1502

050-099 - GPS Satellite Tracking Systems

050	Unspecified	GPS Satellite Tracking System
051	Western Atlas Intl.	Macrometer® V1000
052	Western Atlas Intl.	Macrometer™ II
053	Texas Instruments, Inc.	TI-4100 (GESAR Software)
054	Texas Instruments, Inc.	TI-4100 (TI EPROM Software)
055	Trimble Navigation, Ltd.	4000 series
056	Leica-Wild-Magnavox	WM101,WM102,SR299,399,9500 series,CRS1000
057	ISTAC, Inc.	Model 2002™
058	EDO Canada, Ltd.	EDO JMR GeoTrak
059	Motorola, Inc.	Eagle series
060	Norstar Instruments, Ltd.	Norstar 1000
061	SERCEL Inc.- USA	TR5S, NR101, NR104
062	Western Atlas Intl.	MINI-MAC™

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
****	***********	***********************

050-099 - GPS Satellite Tracking Systems - Continued

063	Ashtech, Inc.	XII series, L-,M-,P-,S- & Z- series
064	Allen Osborne Assoc.,Inc.	Rogue series
065	NovAtel Commun., Ltd.	NovAtel GPSCard,Outrider,Millenium
066	Topcon America Corp.	GP series, TURBO series
067	Del Norte Technology,Inc.	1008,1012
068	Magellan	NAV5000 PRO
069	Javad Positioning Systems	LEGACY,REGENCY,ODYSSEY
070	Sokkia Corporation	GSR 2000 & 3000 series
071	Specra Precision AB	Geotracer 2000 series
072	3S Navigation	R100 series

100-199 - THEODOLITES AND TRANSITS

100	Unspecified	Theodolite or Transit

101-119 - Instruments of Geodetic Astronomy

101	Various	Zenith Telescope
102	Various	Meridian Telescope, Transit, or Circle
103	Various	Bamberg-Type Astronomic Transit
104	Wild	T-4
105	Kern	DKM3-A
106	Gigas-Askania	TPR
107	Zeiss/Jena	Theo-Q02

120-139 - First-Order (Geodetic) Theodolites

120	Unspecified	0."1, 0."2, 0."5 Direct-Reading Theodolite
121	Various	Ramsden-Type 30, 24, 12-inch Theodolite
122	Various	USC&GS Parkhurst
123	Wild	T-3
124	Kern	DKM3
125	CTS/Vickers	Geodetic Tavistock
126	Hilger-Watts	Microptic No. 3

140-159 - Second-Order (Universal) Theodolites

140	Unspecified	1", 2", 5" Direct-Reading Theodolite
141	Various	USC&GS 7-inch Repeating Theodolite
142	Wild	T-2 or T-2E
143	Kern	DKM2 or DKM2-A
144	CTS/Vickers	V-400 Series
145	Hilger-Watts	Microptic No. 2
146	Dietzgen/Askania	A2 or A2E
147	Zeiss/Oberkochen	Th2
148	Zeiss/Jena	Theo-010 or Theo-OlOA
149	Nikon	NT-3 or NT-5
150	Sokkisha	TM-lA
151	Geotec	TH-01

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
****	***********	***********************

160-169 - Third-Order (Construction) Theodolites

160	Unspecified Construction Theodolite or Transit	
161	Various	10" Direct-Reading Theodolite or Transit
162	Various	20" Direct-Reading Theodolite or Transit
163	Various	30" Direct-Reading Theodolite or Transit
164	Various	1' Direct-Reading Theodolite or Transit

170-179 - 30' or Coarser Angulation Devices

170	Unspecified	30' or Coarser Angulation Device
171	Various	30' or Coarser Theodolite or Transit
172	Various	30' or Coarser Compass Device
173	Various	30' or Coarser Protractor

180-199 - Gyroscopic Theodolites

180	Unspecified	Gyro-Theodolite

200-299 - LEVELING INSTRUMENTS

200	Unspecified	Leveling Instrument

210-249 - Precise (Geodetic) Levels

210	Unspecified	Precise Level

211-230 - Precise Spirit (Bubble-Vial) Levels

211	Various	USC&GS Fischer
212	USC&GS	Stampfer-Type (1877-1899)
213	Buff & Berger	Van Orden or Mendenhall
214	Various	Kern-Type (US Engineers)
215	Zeiss	Ni-III or Ni-A
216	Zeiss/Jena	Ni-004
217	Wild	N-3
218	Kern	NK3-M
219	Breithaupt	NABON
220	Fennel	Precise Level
221	Hilger-Watts	Precise Level
222	CTS/Vickers	Geodetic Level
223	Sokkisha	PL-5
224	Keuffel & Esser	Precise Level

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
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231-249 - Precise Compensator (Self-Aligning) Levels

231	Zeiss/Oberkochen	Nil
232	Zeiss/Oberkochen	Ni2
233	Zeiss/Jena	Ni-002
234	Zeiss/Jena	Ni-007
235	Wild	NA-2 or NAK-2
236	Salmoiraghi	5190
237	MOM	Ni-A31
238	Sokkisha/Sokkia	All models
239	Kern	GK2-A
240	Topcon	AT-D2, AT-G2
241	Zeiss	Ni-005A
242	Leica/Wild	NA2000 or NA2002 Digital Level
243	Leica/Wild	NA3000, NA3003 or DNA03 Digital Level
244	TOPCON	DL101 Digital Level
245	TOPCON	DL102 Digital Level
246	ZEISS	DINI10, DINI11 or DINI12 Digital Level

250-289 - Engineer's (Universal) Levels

250	Unspecified	Engineer's Level

251-270 - Engineer's Spirit (Bubble-Vial) Levels

251	Various	18-inch Dumpy-Type Level
252	Various	18-inch Wye-Type Level
253	Zeiss	Ni-II or Ni-B
254	Zeiss/Jena	Ni-030
255	Wild	N-2 or NK-2
256	Kern	NK3
257	Kern	NK2
258	Kern	GK23
259	Breithaupt	NAKRE
260	Fennel	Engineer's Level
261	Hilger-Watts	Engineer's Level
262	CTS/Vickers	Engineer's Level
263	Salmoiraghi	5160 Series
264	Nikon	S2
265	Sokkisha	TTL-5 or TTL-6
266	Geotec	L-11 or L-21

271-289 - Engineer's Compensator (Self-Aligning) Levels

271	Zeiss/Oberkochen	Ni22
272	Zeiss/Jena	Ni-025
273	Kern	GKl-A
274	Breithaupt	AUTOM or AUCIR
275	Fennel	AUING
276	Hilger-Watts	AUTOSET
277	Salmoiraghi	5173, 5175, or 5180
278	Ertel	INA
279	Nikon	AE Series
280	Sokkisha	B-2
281	Geotec	AL-2 or AL-23
282	Sokkisha	C-1

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
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290-299 - Builder's (Construction) Levels

290	Unspecified	Builder's Level
291	Various	Builder's Dumpy-Type Spirit Level
292	Various	Builder's Tilting Spirit Level
293	Various	Builder's Compensator Level

300-399 - LEVELING RODS AND STAFFS

300	Unspecified	Leveling Rod or Staff

310-349 - Precise (Geodetic) Metal-Scale Rods

310	Unspecified	Precise Metal-Scale Rod
311	USC&GS	USC&GS Pre-Invar Rods
312	USC&GS	Invar (Introduced in 1916)
313	Zeiss/Oberkochen	Invar
314	Zeiss/Jena	Invar
315	Wild	Invar
316	Kern	Invar
317	Breithaupt	Invar
318	Fennel	Invar
319	Hilger-Watts	Invar
320	CTS/Vickers	Nilex
321	Salmoiraghi	Invar
322	Keuffel & Esser	Invar
323	Gurley	Invar
324	Renick	Invar (Checkerboard)
325	USGS	Invar (Metal-Frame)
340	Nedo	Invar
341	Nestler	Invar

350-389 - Engineer's Wooden Rods and Staffs

350	Unspecified	Engineer's Wooden Rod or Staff
351	Various	US Engineers 12-foot Rigid Rod
352	Various	US Geological Survey 12-foot Rigid Rod

390-395 - Builder's Rods and Staffs

390	Unspecified	Builder's Rod or Staff
391	Various	Philadelphia Rod
392	Various	Chicago Rod
393	Various	California Rod
394	Various	12-foot Folding Rod
395	Non-invar bar-code rod	Typically fiberglass. Provide details in comment record--manufacturer, number of sections, length, material.

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
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396-399 - Precise (Geodetic) Metal-Scale, Bar-Code Rods

396	Leica/Wild	Invar (Bar-Code) Rod
397	Zeiss	Invar (Bar-Code) Rod
398	Topcon	Invar (Bar-Code) Rod
399	Sokkisha/Sokkia	Invar (Bar-Code) Rod

400-499 - STEEL AND INVAR TAPES

400	Unspecified	Steel or Invar Tape

420-439 - Calibrated Invar Tapes

420	Unspecified	Calibrated Invar Tape
421	Various	25-meter Calibrated Invar Tape
422	Various	50-meter Calibrated Invar Tape
423	Various	100-foot Calibrated Invar Tape

440-459 - Calibrated Steel Tapes

440	Unspecified	Calibrated Steel Tape
441	Various	30-meter Calibrated Steel Tape
442	Various	100-foot Calibrated Steel Tape
443	Various	300-foot Calibrated Steel Tape

460-479 - Uncalibrated Steel Tapes

460	Unspecified	Uncalibrated Steel Tape or Ruler
461	Various	30-meter Uncalibrated Steel Tape
462	Various	100-foot Uncalibrated Steel Tape
463	Various	300-foot Uncalibrated Steel Tape

500-599 - LIGHTWAVE DISTANCE-MEASURING EQUIPMENT (DME)

500	Unspecified	Lightwave Electro-Optical DME
501	AGA	Geodimeter Model 1
502	AGA	Geodimeter Model 2 or 2A
503	AGA	Geodimeter Model 3
504	AGA	Geodimeter Model 4A, 4B, or 4D
505	AGA	Geodimeter Model 4L or 4L 10A
506	AGA	Geodimeter Model 6
507	AGA	Geodimeter Model 6A
508	AGA	Geodimeter Model 6B
509	AGA	Geodimeter Model 6BL
510	AGA	Geodimeter Model 7T
511	AGA	Geodimeter Model 700 or 710
512	AGA	Geodimeter Model 76 or 78
513	AGA	Geodimeter Model 8
531	Keuffel & Esser	LSE Ranger I, II, or III
532	Keuffel & Esser	LSE Ranger IV
533	Keuffel & Esser	LSE Ranger V
534	Keuffel & Esser	LSE Rangemaster
535	Keuffel & Esser	Rangemaster II

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
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536	Keuffel & Esser	Uniranger

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
****	***********	***********************

500-599 - LIGHTWAVE DISTANCE-MEASURING EQUIPMENT - CONTINUED

541	Spectra-Physics	Geodolite 3G
542	Spectra-Physics	Transitlite LT-3
551	Kern	ME-3000 Mekometer
561	Cubic Precision	Rangemaster III
562	Cubic Precision	Ranger V-A
571	Leitz	Red 2L

600-699 - INFRARED DISTANCE-MEASURING EQUIPMENT

600	Unspecified	Infrared Electro-Optical DME
601	AGA	Geodimeter Model 12 or 12A
602	AGA	Geodimeter Model 78,110,114,116
603	AGA	Geodimeter Model 210 or 220
604	AGA	Geodimeter Model 120 or 216
605	AGA	Geodimeter Model 6000
606	AGA	Geodimeter Model 14 or 14A
607	AGA	Geodimeter Model 112 or 122
611	Plessey	Tellurometer CD-6
612	Plessey	Tellurometer MA-100
613	Plessey	Tellurometer MA-200
616	Lietz	Red Mini 2
617	Lietz	Red 2A
621	Wild	Distomat DI-3 Series
622	Wild	Distomat DI-10 Series
623	Wild	Distomat DI-4L
624	Wild	Distomat DI-5 or DI-5S
625	Wild	DI 1000 or 1000L
626	Wild	DI 2000
627	Wild	DI 3000 (time-pulse)
628	Leica/Wild	DI 2002
629	Leica/Wild	DI 1600
631	Kern	DM-500
632	Kern	DM-1000 or DM-2000
633	Kern	DM 104 or DM 150
634	Kern	DM 503 or DM 550
635	Kern	DM 504
641	Zeiss/Oberkochen	SM 11 or RegElta 14
642	Zeiss/Oberkochen	Eldi Series
643	Zeiss/Oberkochen	SM 4
651	Keuffel & Esser	LSE Microranger or Microranger II
652	Keuffel & Esser	LSE Autoranger
661	Hewlett-Packard	3800A or 3800B
662	Hewlett-Packard	3805 or 3810
663	Hewlett-Packard	3808A
667	Pentax	MD-14 or MD-20
671	Cubic Precision	Cubitape DM-60
672	Cubic Precision	HDM-70

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
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600-699 - INFRARED DISTANCE-MEASURING EQUIPMENT - CONTINUED

673	Cubic Precision	DM-80 or DM-81
674	Cubic Precision	AutoRanger II
675	Cubic Precision	Beetle 500 or 500S
676	Cubic Precision	Beetle 1000 or l000S
681	Carrol & Reed	Akkuranger Mark I
685	Topcon	DM-C2
686	Topcon	DM-A2 or DM-A3
687	Topcon	DM-S2 or DM-S3
688	Topcon	GTS-2R
693	Nikon	ND 20 or ND 21 or ND 26
694	Nikon	ND 30 or ND 31

700-799 - MICROWAVE DISTANCE-MEASURING EQUIPMENT

700	Unspecified	Microwave Electro-Magnetic DME
701	Plessey	Tellurometer MRA-1
702	Plessey	Tellurometer MRA-2
703	Plessey	Tellurometer MRA-3
704	Plessey	Tellurometer MRA-4
705	Plessey	Tellurometer MRA-5
709	Plessey	Tellurometer CA-1000
731	Wild	Distomat DI-50
732	Wild	Distomat DI-60
741	Cubic	Electrotape DM-20
751	Fairchild	Microchain

800-899 - TOTAL STATION-MEASURING EQUIPMENT

800	Unspecified	Total Station

801-860 - Self Contained Instruments

801	Leitz	SDM3F or SDM3FR
802	Leitz	SET 2
803	Leitz	SET 3
804	Leitz	SET 4
810	Nikon	NTD-4
811	Nikon	NTD-2S
812	Nikon	DTM1
813	Nikon	DTM5
816	Geotronics AB	Geodimeter 142
817	AGA	Geodimeter 140
821	Pentax	PX20D
822	Pentax	PX10D
823	Pentax	PX06D
824	Pentax	PTS-10

CODE	MANUFACTURER	INSTRUMENT MODEL OR TYPE
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801-860 - Self Contained Instruments - Continued

825	Pentax	PTS-1110
826	Pentax	PTS-1105
830	Topcon	GTS or GTS-2R
831	Topcon	GTS-3B or GTS-3C
832	Topcon	ET-1 or ET-2
833	Topcon	GTS-4A or GTS-4B
840	Wild	TC1600
841	Wild	TC2000
842	Leica/Wild	TC2002
850	Zeiss	ELTA 3
851	Zeiss	ELTA 4
856	Hewlett-Packard	3820A

861-899 - Modular Instruments

861	Kern	E1/DM504
862	Kern	E2/DM504
871	Leitz	DT2/Red Mini 2
872	Leitz	DT2/Red 2A or Red 2L
881	Wild	T1000
882	Wild	T1600
883	Wild	T2000 or T2000S
884	Wild	T2002
885	Leica/Wild	T3000

900-999 - OTHER MISCELLANEOUS SURVEYING EQUIPMENT

900	Unspecified	Miscellaneous Surveying Equipment

ANNEX G

ELLIPSOID HEIGHT ORDER-AND-CLASS (OC) CODES

This annex contains ellipsoid height Order and Class (OC) codes. Effective July 1, 2012, these codes were replaced by ellipsoid height network and local accuracies, which are recorded in the *91* and *92* records, respectively, as described in Chapter 2 of the Bluebook. Network and local accuracies have been determined for all GPS projects loaded into the NGS Integrated Data Base since the 2011 national adjustment. Annex G is provided as documentation of legacy data; ellipsoid height codes are no longer used for current geodetic control.

The two-digit ellipsoid height codes were used to classify each ellipsoid height value observed and adjusted at horizontal control points. The first character of the OC code indicates the order and the second character the class, in accordance with the following classification:

OC Code	Classification	b = Maximum Height Difference Accuracy
11	First Order, Class I	0.5
12	First Order, Class II	0.7
21	Second Order, Class I	1.0
22	Second Order, Class II	1.3
31	Third Order, Class I	2.0
32	Third Order, Class II	3.0
41	Fourth Order, Class I	6.0
42	Fourth Order, Class II	15.0
51	Fifth Order, Class I	30.0
52	Fifth Order, Class II	60.0

The ellipsoid height difference accuracy **(b)** is computed from a minimally constrained, correctly weighted, least squares adjustment by the formula:

b = s / sqrt(d)

where: **d** = horizontal distance in kilometers between control points.
s = propagated standard deviation of ellipsoid height difference in millimeters between control points obtained from the least squares adjustment.

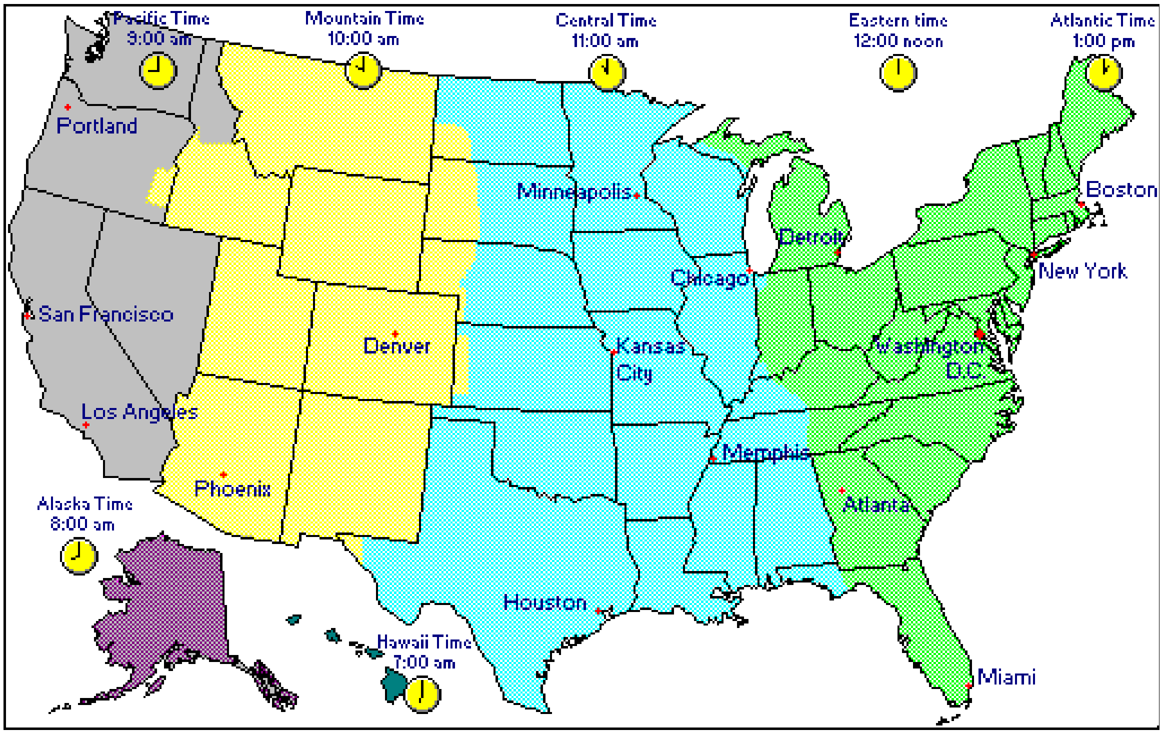
The following table lists the standard errors of ellipsoid height differences at various distances:

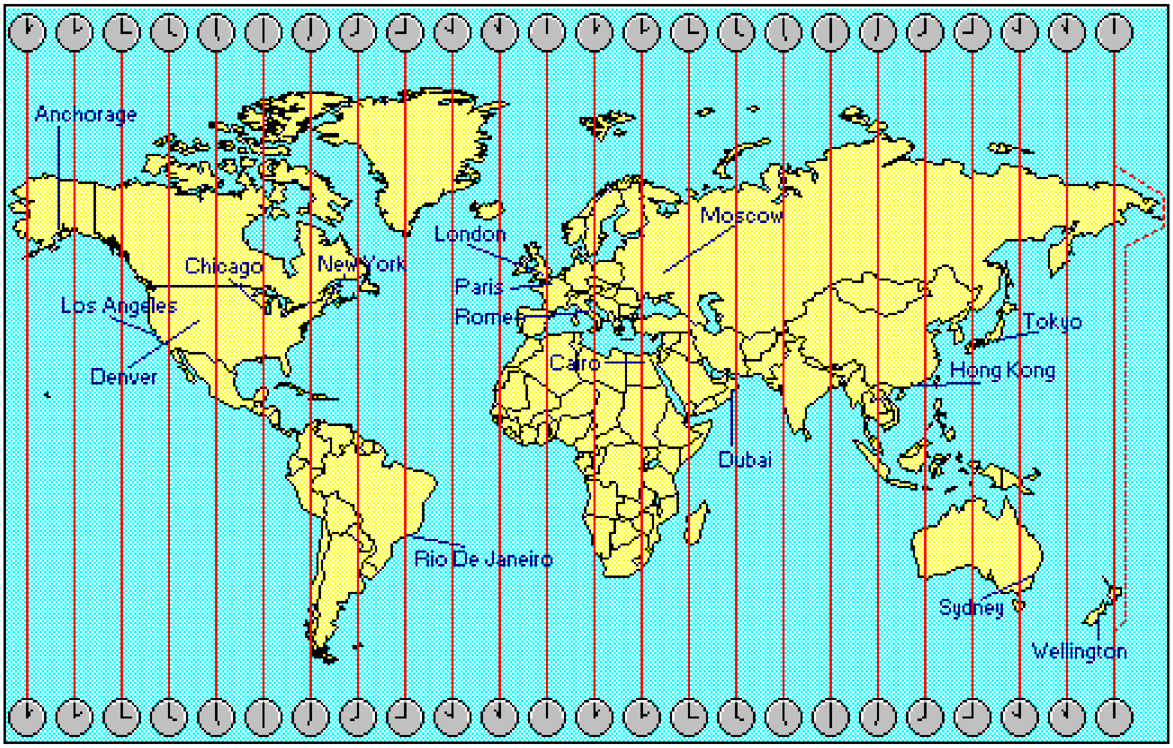
Standard Error (mm)

OC Code

Distance (km)	11	12	21	22	31	32	41	42	51	52
1	.5	.7	1.0	1.3	2	3	6	15	30	60
5	1.1	1.6	2.2	2.9	4.5	6.7	13	34	67	134
10	1.6	2.2	3.2	4.1	6.3	9.5	19	47	95	190
25	2.5	3.5	5.0	6.5	10	15	30	75	150	300
50	3.5	4.9	7.1	9.2	14	21	42	106	212	424
75	4.3	6.1	8.7	11	17	26	52	130	260	520
100	5.0	7.0	10	13	20	30	60	150	300	600

Annex - H
Standard Time Zones





ANNEX K

REPORT INSTRUCTIONS for Leveling Projects and Horizontal (Non-GPS)Projects
--For GPS Project Report Instructions see ANNEX L, Section 9.0--

Information concerning data preparation and transmittal to NGS is found in Bluebook Chapter 1, HORIZONTAL CONTROL (HZTL) DATA and Chapter 5, VERTICAL CONTROL (VERT) DATA. Refer to the section titled "Media for Submitting Data" in those chapters. All submitted files may be digital (computer-generated). These must be on media approved by NGS at the time of submission–-currently CD and floppy disk, but subject to changes in technology. The transmittal letter should inventory the total contents of the shipment. Instructions for submitting GPS relative positioning data to the NGS are provided in ANNEX L.

The most important supporting document to be included with the shipment is the project report. It is the permanent record that summarizes project accomplishments. It describes the general project goals and the equipment and procedures employed to meet specific conditions and requirements. The report provides information useful for verification and adjustment, including detailed explanation of unusual or special features of the project. The recommended content of a project report follows. For projects totally or partially supported by NGS, a different report may be required.

Report Outline for a Vertical Control Project

I. Title page. List the type of report (Vertical Control), order and class of survey, project title including the state, any appropriate identifying number (for projects that have been assigned HGZ accession numbers by NGS, the numbers should be listed on the title page), beginning and ending dates of both mark setting and leveling, agency name, and the name of the project director (supervisor). The project title should include the locality of the project.

   Cross-reference any GPS project that was done in conjunction with the leveling.

II. The report should address the following topics:

   A. Location. Briefly describe the project area, including state or states in which it is located. Note the number of lines, their general configuration, and their total distance.

   B. Scope

      1. Purpose. State the purpose of the survey and the extent to which the requirements were satisfied.

      2. Specifications. State the specifications which were followed and the methods used.

      3. Monumentation. Describe the monumentation that was established and recovered.

      4. Instrumentation. Describe the equipment, including a list of instruments, rods (including calibration information), and recording equipment. Include model and serial numbers of all equipment and the dates they were in use. Note the reasons for return of equipment for repairs or adjustment. For rod calibrations, cite which previously submitted calibration data are to be used to process the project. If none was submitted previously, include such calibration data with the leveling data submitted with this report.

C. Comments (THE MOST IMPORTANT SECTION OF THE REPORT)

1. Reconnaissance. If a reconnaissance plan was submitted and approved by NGS prior to beginning the field measurements, describe any changes from the original reconnaissance and the reasons for the changes.

2. Specifications. Describe any deviations from the specifications used and the reason for such deviations.

3. Routes. Briefly describe each line, including line number or other identification, topography and climate, features of the routing such as control point spacing and frequency of connections, unusual points leveled, unusual procedures, river or valley crossings, and ties established.

4. Problems. Describe all problems encountered, such as: moved or "suspect" marks, systematic new-minus-old comparisons, poor ground or atmospheric conditions, etc.

5. Recommendations. Mention specific sections that required additional work as a result of preliminary analysis. Describe areas which may require additional leveling in the future.

D. Statistics

1. Closures. List loop closures for all loops of concurrent surveys. State the accumulated forward-backward difference for each line.

2. Check-measurements. Compute and list new-minus-old tabulations for all releveling of previously leveled lines. Also, list the average and maximum disagreements.

3. Progress. (Needed only if submitting organization is supported by NGS funding and/or equipment). Total progress along lines, double-run progress, single-run progress, total distance leveled, distance leveled as reruns, and number of sections.

4. Reruns. For all sections that were releveled for any reason other than those exceeding the tolerance limit, list the sections and the reasons for releveling.

E. Status

1. Records. Describe the current status and future disposition of the station and observation records. If submitted to NGS, they will be archived in a Federal records center.

2. Contact. Provide the name and telephone number of a person to contact regarding questions which may arise during NGS processing of the data.

III. Attachments to the report. Include as an attachment to the report a simple sketch of the project area showing completed lines, junctions, and loops. A section of the State Index Map of Control Leveling is sufficient with progress marked and lines clearly labeled. Also, attach copies of sketches showing loop closure computations.

Mailing Information

To submit leveling data to NGS, contact the Observations and Analysis Division at 301-713-3176 for the address.

Report Outline for a Horizontal Control Project

I. Title page. List the type of report (Horizontal Control), order-class of survey, project title including the state, the project number if it has been assigned, beginning and ending dates of field work, agency name, and the name of the project director. The project title should include the locality of the survey (e.g., Brainerd to Crosby, MN).

II. The report should address the following topics:

  A. Location. Briefly describe the project area, indicating each state and the counties in which the project is located.

  B. Scope

    1. Purpose. State the purpose of the survey and the extent to which the requirements were satisfied.

    2. Specifications. State the specifications which were followed and the methods used.

    3. Monumentation. Describe the monumentation that was established and recovered.

    4. Instrumentation. List the instruments and equipment used. For EDMI, describe the instrument calibration and how the calibration and refractive index corrections were applied. Include model and serial numbers of all instrumentation.

    5. Special equipment. List any special equipment used. Examples include Bilby towers, helicopters, wooden stands, Peck towers, etc.

    6. Existing control. List the designation and PID of NSRS stations that were 1) held fixed and 2) readjusted in the project. Include all bench marks used to control the elevations. For existing horizontal control <u>not connected</u> to the new survey, include an explanation of why connections were not made.

  C. Comments (THE MOST IMPORTANT SECTION OF THE REPORT)

    1. Reconnaissance. When a reconnaissance plan was submitted and approved by NGS prior to beginning the field measurements, describe any changes from the approved plan and the reasons for the changes.

    2. Specifications. Describe any deviations from the specifications used and the reason for such deviations.

    3. Computations. Describe which computations were performed, the coordinate system used (e.g., latitude and longitude, state plane, or local rectangular grid), and what type of adjustment, if any, was performed.

    4. Problems. Describe any problems encountered such as: moved or suspect marks, bad check angles, and poor checks in position, azimuth, and length.

5. Recommendations. Describe any recommendations for future field measurements and/or recomputation of published data.

D. Statistics

1. Points. List the number of points positioned grouped by type of mark such as: new main scheme, old main scheme, and/or landmark stations.

2. Observations. List the number of observations and their precision grouped by type of observation such as: horizontal directions, zenith distances, vertical angles, distances, and astronomic azimuths.

3. Closures

a. Triangle. List the number of triangles, the average triangle closure, and the maximum triangle closure. For the maximum triangle closure, identify the three vertices.

b. Traverse. For each traverse closure, identify the traverse segment and list the azimuth closure, the position closure, the total length, the number of courses, and the minimum course length.

4. Reoccupations. List any reoccupied stations, the lines reobserved, and the reason for the remeasurement.

5. Check measurements. List comparisons between previously observed angles (check angles) and/or distances with current observations. Also, list the average and maximum disagreements.

6. Fixed measurements. List comparisons between computed observations (computed from existing coordinate data) and current observations. Also, list the average and maximum disagreements.

E. Status

1. Records. Describe the current status and future disposition of the station and observation records. If submitted to NGS, they will be archived in a Federal records center.

2. Contact. Provide the name and telephone number of a person to contact regarding questions which may arise during NGS processing of the data.

III. Sketch

Include an original scale drawing [sketch] of the project area. A digital version of the sketch, such as in .jpg format, is requested as well as the hard copy. The sketch will show station names and lines which were observed for angles and distances. To ensure that reproductions and film reductions of sketches are of optimum quality, sketches should not be drawn on maps. Although linen, mylar or vellum is desirable, it is not required. A 24" x 36" sketch is preferred, but the size should not exceed 36" x 48". The border will show latitude and longitude tick marks. The names of main scheme stations will be placed adjacent to the station symbol. Supplemental stations may be numbered for reference to a list of names. Submitting agency or organization name should appear in a title block. The sketch may be handlettered.

Use the following standard symbols on sketches. Similar symbols and notations are explained in C&GS Special Publication 247, pp. 6 and 191-192.

(a) Squares for existing vertical network control
(b) Open triangles for existing horizontal control stations
(c) Open triangles within squares for existing horizontal/vertical stations

Besides the stations occupied, the sketch should show other stations of the existing network located within or near the project area. Specify in the project report whether any attempt was made to recover these stations. The report must state why the recovered stations were not occupied. To show a station that was not recovered use "NR" next to that station's symbol. The sketch shall include a boxed-in legend that gives:

(a) project name
(b) general locality
(c) name of group making observations
(d) project leader
(e) beginning and ending dates, month/year
(f) scale

Survey points will be shown in an inset when they are too close together to be depicted clearly on the network sketch.

Mailing Information

To submit horizontal data to NGS, contact the Observations and Analysis Division at 301-713-3176 for the address.

REFERENCE

Gossett, F.R., 1950, rev. 1959: Manual of geodetic triangulation. C&GS Special Publication 247, 344 pp. National Geodetic Information Branch, NGS, NOAA, Silver Spring, MD 20910.

ANNEX L

GUIDELINES FOR SUBMITTING GPS RELATIVE POSITIONING DATA

Requirements and options are described below for submitting Global Positioning System (GPS) relative positioning data to the National Geodetic Survey (NGS) for inclusion in the National Spatial Reference System (NSRS). The submission may be completely digital on CD. Include a transmittal which inventories the shipment.

Prior to beginning a project, obtain approval for it from NGS, Project Development Branch. Access the Survey Project Proposal form or call 301-713-3194. You may also begin this review process with your state advisor.

1.0 GPS OBSERVATIONS (R-files): Submit the raw GPS observations (receiver manufacturer's proprietary format) for each occupation of a station. Organize the files in a "RAW" or similar-named folder under which there are session folders, such as 173A, 173B, 176A. If the 4-character ID of a station was not used in the file name[s] for a station, place the file[s] in a sub-folder named for the 4-character ID. Also submit the RINEX files created from the raw files, in session folders under a "RINEX" folder.

2.0 GPS VECTOR SOLUTIONS (G-file): Submit one G-file for each project in the formats specified in Bluebook Annex N, which is posted at the Bluebook web site, http://www.ngs.noaa.gov/FGCS/BlueBook/. The G-file is created by vendor software or SINEX2G and contains:

(1) From/to station identification using station serial numbers (SSNs) and 4-character IDs.
(2) Vector coordinate differences (DX, DY, DZ), standard deviations, and correlations (or covariances)
(3) Name and version of processing software
(4) Date of solution
(5) Source of the ephemerides (GPS orbits)
(6) Coordinate system (datum) for the vectors
(7) Solution type
(8) Method of vector processing (three methods, discussed next)

Single-vector processing uses data from two stations at a time within a session. Mathematical correlations between vectors are not computed. The resulting G-file may include independent and dependent vectors. There will be n(n-1)/2 of these (total) for each session, where n is the number of receivers observing. If only (n-1) independent vectors are submitted, select fixed integer bias solutions (typically associated with shorter vectors) in preference to float solutions.

Multiple-vector or session processing generates correlations between vectors in a session. The resulting G-file entries correspond to the (n-1) independent vectors.

The network reduction method combines multiple sessions into one SINEX file from which the G-file is derived. The G-file in this case contains (s-1) independent vectors, where s is the total number of unique stations in the solution.

Specify the solution coordinate reference system used (the reference frame of the GPS orbits) by selecting the associated numeric code from a table in Annex N. Submit NAD 83 station coordinates, which are obtained by transformation from the orbital reference frame, either automatically by vendor software or within ADJUST.

2.1 Four-character station ID (4-char ID), data media identifier, and Serfil:

The submittal process requires that each occupied station be identified by both a 4-char ID and a station serial number (SSN); also that an auxiliary text file, the "Serfil" be created to cross-references these two items. The format of the Serfil is: columns (cc) 1-4, 4-char ID; cc 5-7, blank; cc 8-11, SSN.

The 4-char ID is intended to be a shortened version of the full station name for use in naming data files and plotting on the project sketch. The data media identifier is a 10-character text string such as “A1734AMOB1" noting the receiver code, day of year, last digit of year, session and 4-char ID. It is discussed more fully in Bluebook Annex N, p. N–11, and in brief must occur identically in both the B- and G-files for a given occupation of a station.

3.0 GPS PROJECT AND STATION DATA (B-file): Submit one B-file for each project in the formats specified in Bluebook Chapters 1 and 2. Use NGS software CR8BB (documentation in (NGS 2004) or a text editor. The B-file contains:

(1) project title, location, start/stop dates, etc.
(2) station occupation information (4-character ID, SSN, data media identifier, observer's initials, receiver and antenna used, vertical antenna height measurements, operator comments, etc.)
(3) equipment information (make, model and serial number of receivers and antennas)
(4) station names and best estimates for station coordinates and heights

4.0 STATION DESCRIPTIONS (D-file): Submit one D-file for each project in the formats specified in Bluebook Annex P. The D-file is created by WinDesc. It contains original descriptions for new marks and recovery information for existing stations. It includes all occupied GPS points and (optionally) NSRS points visited but not occupied during the project.

Datasheets for existing NSRS points in a project area can be downloaded from the NGS website. The datasheet file can be imported into WinDesc.

5.0 HORIZONTAL CONNECTION SURVEY DATA (T-file): No longer accepted per Addendum V of **POLICY OF THE NATIONAL OCEAN SERVICE REGARDING THE INCORPORATION OF GEODETIC DATA OF OTHER ORGANIZATIONS INTO THE NATIONAL GEODETIC SURVEY INTEGRATED DATA BASE**

6.0 VERTICAL CONNECTIONS (L-file or other): If leveling that meets FGCS specifications has been observed to points in the GPS project, submit one L-file for each part number in the leveling project in the formats specified in Bluebook Chapters 5 and 6. This is generally first- or second-order work, with the required three- or two-mark ties made. Cross-reference the leveling project and the GPS project to each other in the respective project reports. See Annex K for instructions on the leveling project report and submittal.

Lower-order leveling data should be included in the GPS B-file *45*-*47* records and discussed in the GPS project report. This generally occurs when a new mark is tied from only one existing mark and the GPS observations are used as a check.

7.0 LEAST SQUARES ADJUSTMENTS: Refer to the Constrained Adjustment Guidelines.

8.0 PROJECT SKETCH: Submit a sketch showing all stations occupied during the GPS survey. Show latitude and longitude grid ticks around the border. Use the following symbols as a guide:

(a) Squares for existing vertical control
(b) Open triangles for existing horizontal control stations
(c) Open triangles within squares for existing horizontal/vertical control
(d) Solid triangles for GPS stations
(e) Circles for stations occupied during previous GPS projects

Include a legend showing:

(a) project name & general locality
(b) name of group making observations
(c) project director
(c) beginning and ending dates, month/year
(e) scale of sketch

Show points in a large-scale inset when they are too close together to be depicted clearly at map scale.

9.0 PROJECT REPORT:

The most important document to be included with the shipment is the project report. It describes project goals, conditions and requirements and the personnel, equipment and procedures employed to meet them. The report assists problem resolution and data adjustment by detailed explanation of unusual or special project features. Use the following categories as a guide. NGS-supported projects may require a different report.

9.1 Introduction

A. Agency and Purpose - State the name of the organization which performed the survey and the purpose[s] for which the survey was done.

B. Accuracy standards - Provide the vertical and horizontal accuracy standards specified for the project.

C. Time Period - State the arrival and departure dates for the field crew and dates of first and last observing sessions.

D. Point of Contact - Supply the name, phone number, email address and mailing address of the point of contact within the submitting organization. Supply the same information for all organizations which participated in the survey.

9.2 Location - Describe the geographic location and extent of the project.

9.3 Conditions Affecting Progress - Note any factors which facilitated or impeded the project.

9.4 Field Work–-discuss the following:

A. Reconnaissance and mark-setting

B. Chronology, the progress of the project.

C. Instrumentation - Summarize the make and model of the receivers and antennas used in the project. Indicate any unusual or faulty equipment.

D. Weather - List all observing sessions which occurred during periods of changing or severe weather conditions such as passing fronts, storms, etc. Details should be narrated on the field log sheets.

E. Deviation from Instructions - Describe any deviation from the procedures and specifications stated in the project instructions. Specify all stations which were eccentrically occupied and state why the station(s) could not be directly occupied.

9.5 Data Processing Performed - Describe the data processing that was done. Include tasks such as transferring data to different storage media, checking data quality (eg, running teqc or submitting files to OPUS for initial coordinates), analyzing differences in repeat vectors, and writing station descriptions. Specify the ephemeris type used (broadcast, rapid, ultra-rapid, precise, etc.) and the source (IGS, NGS, DMA, etc.).

A. Software Used - Specify all software by name and version which was used to acquire, manage, reduce, adjust, and submit field data. If the project data were reduced or acquired with different versions of a program, specify which version was used with which block of data.

B. Rejected Data - Specify vectors which were rejected and possibly reobserved. Include the reason(s) for the rejection, such as failed equipment or bad weather listed under Field Work sections B or C above.

C. Adjustment - Discuss in detail the adjustments performed. Show weighting technique used, station(s) constrained, method used to estimate orthometric heights and existence of any independent sub-networks. Discuss possible weaknesses or distortions found or suspected in the NSRS.

9.6 Comments and Recommendations

Include comments and recommendations not found elsewhere in the project report.

9.7 Attachments and Enclosures

A. Station List - Include a table which lists the station name, 4-char ID, session(s) occupied, and station type (existing horizontal or vertical, new station, etc.) for all stations occupied.

B. Project Sketch - per section 8.0. If there are multiple copies of the sketch showing different data, attach a copy of each.

C. Project Instructions - Attach a copy of the instructions and/or contract under which the project was performed. Include any revisions or changes to the instructions or specifications.

D. Field Logs - Provide original, scanned or clean copies of observation logs, field notes, record books and any weather observations.

E. Equipment Failure Logs (NGS projects) - Include a failure log for any equipment used to gather data which failed anytime during the project. State the type of component, serial number, date of failure and nature of failure.

F. Project Observing Schedule - Prepare a list containing the following: observing days/sessions, 4-char IDs and station names, session start and stop dates and times (UTC).

****

All data and material submitted must be neat and legible (typed or clearly written in black ink).

RETAIN A COPY OF ALL PAPER RECORDS AND DIGITAL DATA FILES.

****

10.0 PROJECT SUBMISSION CHECKLIST: Exhibit A is a form that may be used to check for completeness when submitting GPS project data to NGS.

11.0 DATA TRANSMISSION MEDIA: Submit digital data files to NGS on media approved by NGS at the time of submission–-currently CD/DVD. These are subject to changes in technology.

To obtain the address for submitting a completed GPS project to NGS and/or if you have questions concerning the above requirements, please contact the Observations and Analysis Division at 301-713-3176.

EXHIBIT A

SUBMISSION CHECKLIST, GPS PROJECTS
Any or all items may be digital

Project Title: ______________________________

Submitting Agency: ______________________________

Observing Agency: ______________________________

Receiver Type: ______________________________

PACKAGE CONTENTS

Project Report and Attachments	Required For
( ) NGS approval of proposed project, email/memo	All Projects
( ) Approved Reconnaissance and Project Sketch	All Projects
( ) Project Instructions or Contract Specifications	All Projects
( ) Final Station List	All Projects
( ) Final Observing Schedule	All Projects
( ) Observation Logs	All Projects
( ) Equipment Failure Logs	NGS Projects
( ) Loop Misclosures	Optional
( ) Free Horizontal Adjustment with Analysis (NAD83)	All Projects
( ) Constrained Horizontal Adjustment (NAD83)	All Projects
( ) Free Vertical Adjustment (NAVD 88 Heights)	All Projects
( ) Constrained Vertical Adjustment (NAVD 88 Heights)	All Projects
( ) Photographs or Rubbings of Station Marks	All Projects
( ) Photographs of Views from Stations	Recommended
( ) Obsdes Output (Validation program--B/D-files)	All Projects
( ) Chkobs Output (Validation program--B-file)	All Projects
( ) Obschk Output (Validation program--B/G-files)	All Projects
( ) WinDesc Check Output (Validation program--D-files)	All Projects
( ) Project Report	All Projects
( ) Phase Data, raw and RINEX (R-files)	All Projects
( ) Base Line Vectors (G-file)	All Projects
( ) Project and Station Occupation Data (B-file)	All Projects
( ) Descriptions and/or Recovery Notes (D-file)	All Projects
( ) Serfil	All Projects
( ) Differential Leveling Observations (L-file)	If Applicable

Comments - Enter on the reverse side of this form.

REFERENCES:

Defense Mapping Agency, 1987: “Department of Defense World Geodetic System 1984 - its definition and relationships with local geodetic systems.” DMA Technical Report, DMA TR 8350.2, 30 September 1987, Washington, DC.

Federal Geodetic Control Committee (FGCC), 1989: "Geometric Accuracy Standards and Specifications for GPS Relative Positioning Surveys, version 5.0", reprinted with corrections August 1, 1989.

Federal Geodetic Control Subcommittee (FGCS): “Input Formats and Specifications of the National Geodetic Survey Data Base”.

Vincenty, T., 1987: "On the use of GPS vectors in densification adjustments," Surveying and Mapping (Journal of the American Congress on Surveying and Mapping), Vol. 47, No. 2, pp. 103-108.

NOTE: National Geodetic Survey and Federal Geodetic Control Subcommittee publications are available online as listed above and/or from:

NOAA, National Geodetic Information Branch, N/NGS12
voice: 301-713-3242
fax: 301-713-4172

NGS and other publications

ANNEX M

NGS GPS ANTENNA CODES

[This Annex supersedes Annex J]

The first record field of this table lists the GPS Antenna Codes to be used in the *72* record, which supersedes the *71* record for listing antenna types/serial numbers for a project. Older Blue Book files that have *71* records will continue to be accepted by NGS. The first three characters of the GPS ANTENNA CODE represent an abbreviation for the manufacturer. For most antennas the model number or part number is also represented as part of the GPS ANTENNA CODE, as is the type of radome used. The second record field gives a brief description of each antenna.

If an unlisted antenna is used from one of the known manufacturers shown below, then use its corresponding "_OTHER" code (Example: If you are using a Trimble antenna not listed in Annex M, use the "TRM_OTHER" code). If you have an antenna whose manufacturer is not listed, then use the "XXX_OTHER" code. When using any of these "_OTHER" codes, you should include a *26* record in the B-file that describes the unlisted antenna for each station occupation. Annex M will be modified to incorporate new antennas.

If you are using a geodetic GPS antenna that is dual-frequency but is not listed in Annex M, please notify NGS by sending an e-mail to **cors@ngs.noaa.gov** so we can make arrangements to derive an antenna pattern and antenna code for that antenna.

The manufacturer abbreviations identified by the first three characters of the GPS ANTENNA CODE are:

AER - AeroAntenna
AOA - ALLEN OSBORNE AND ASSOCIATES
ASH - ASHTECH
JPL - JET PROPULSION LABORATORY
JPS - JAVAD POSITIONING SYSTEMS
LEI - LEICA
MAC - MACROMETRICS
NOV - NOVATEL
SEN - SENSOR SYSTEMS
SOK - SOKKIA
TOP - TOPCON
TRM - TRIMBLE

The most recent list of GPS antennas is shown on the following pages.

```
GPS ANTENNA CODES    NAME/DESCRIPTION OF ANTENNA
******************** ****************************************
NONE                 NONE
AERAT2775_42                    Geodetic L1/L2
AERAT2775_43    SPKE Choke Ring Geodetic L1/L2 + radome
AERAT2775_43         Choke Ring Geodetic L1/L2
AERAT2775_62         L1/L2
AOAD/M_B             Dorne Margolin B, chokerings (Rogue)
AOAD/M_TA_NGS        Dorne Margolin T,chokerings,Ashtech LNA
AOAD/M_T             Dorne Margolin T, chokerings (TurboRogue)
ASH110454            ProAntenna   L1
ASH700228A           Geodetic L1/L2, 8 holes, bubble,compass
ASH700228B           Geodetic L1/L2, 8 holes, bubble,compass
ASH700228C           Geodetic L1/L2, 8 holes,no bubble,compass
ASH700228D           Geodetic L1/L2, REV.B, 8 L-shaped notches
ASH700228E           Geodetic L1/L2, REV.B, 8 L-shaped notches
ASH700700.A          Marine L1/L2
ASH700700.B          Marine L1/L2
ASH700700.C          Marine L1/L2
ASH700718A           Geodetic III 'Whopper', REV. D
ASH700718B           Geodetic III 'Whopper', REV. D
ASH700829.2     SNOW Geodetic III 'Whopper' (USCG) +radome
ASH700829.3     SNOW Geodetic III 'Whopper' (USCG) +radome
ASH700829.3     SNOW Geodetic III 'Whopper' (USCG) +radome
ASH700829.A     SNOW Geodetic III 'Whopper' (USCG) +radome
ASH700829.A1    SNOW Geodetic III 'Whopper' (USCG) +radome
ASH700829.A1    SNOW Geodetic III 'Whopper' (USCG) +radome
ASH700936A_M         D/M element, milled chokerings, -radome
ASH700936A_M    SNOW D/M element, milled chokerings, +radome
ASH700936B_M         D/M element, milled chokerings, -radome
ASH700936B_M    SNOW D/M element, milled chokerings, +radome
ASH700936C_M         D/M element, milled chokerings, -radome
ASH700936C_M    SNOW D/M element, milled chokerings, +radome
ASH700936D_M    SNOW D/M element, milled chokerings, +radome
ASH700936D_M         D/M element, milled chokerings, -radome
ASH700936E      SNOW D/M element, REV E, chokerings, +radome
ASH700936E           D/M element, REV E, chokerings, -radome
ASH700936E_C         D/M, chokerings, 700936.02 REV E, SCIGN
ASH701008.01B        Geodetic IIIA, P/N:701008-01(B)
ASH701073.1          GPS/GLONASS,REV.1,chokerings
ASH701073.3          GPS/GLONASS,REV.3,chokerings
ASH701933A_M         D/M element,REV.A,chokerings,H2Otight
ASH701933A_M    SNOW D/M element,REV.A,chokering,H2Otight,rd
ASH701933B_M         D/M element,REV.B,chokerings,H2Otight
ASH701933B_M    SNOW D/M element,REV.B,chokering,H20tight,rd
ASH701933C_M         D/M element,REV.C,chokerings,H2Otight
ASH701933C_M    SNOW D/M element,REV.C,chokering,H20tight,rd
ASH701941.021        D/M element,REV.1,chokerings,GPS+GLONASS
ASH701941.022        D/M element,REV.2,chokerings,GPS+GLONASS
ASH701941.1          D/M element,REV.1,chokerings,GPS+GLONASS
ASH701941.2          D/M element,REV.2,chokerings,GPS+GLONASS
ASH701945.02B        D/M element,REV.B,chokerings
ASH701945B_M         D/M element,REV.B,chokerings
ASH701945C_M         D/M element,REV.C,chokerings
ASH701946.022        D/M element,REV.2,chokerings,GPS+GLONASS
ASH701975.01         Geodetic IV, Rev.A
ASH701975.01+GP      Geodetic IV, Rev.A with groundplane
```

JPLD/M_R		Dorne Margolin R, chokerings (Rogue,JPL)
JPSLEGANT_E		Legant on flat groundplane, External
JPSREGANT_DD_E		Regant dual depth chokerings, External
JPSREGANT_SD_E		Regant single depth chokerings, External
LEIAT202-GP		External micropulse L1/L2 -groundplane
LEIAT302-GP		External micropulse L1/L2 -groundplane
LEIAT303		Micropulse chokering antenna -radome
LEIAT303	LEIC	Micropulse chokering antenna +radome
LEIAT502		Aero element L1/L2, External
LEIAT503		Micropulse chokering antenna -radome
LEIAT503	LEIC	Micropulse chokering antenna +radome
LEIAT504		D/M element, chokerings, -radome
LEISR299_INT		SR299, Internal with Ball element L1/L2
LEISR399_INT		SR399, Internal with Ball element L1/L2
MAC4647942	MMAC	Macrometer crossed-dipole, +radome
MAG105645		L1/L2 GPS
NGSD/M+GP60		D/M antenna with extended groundplane
NOV501		GPS-501 L1
NOV501+CR		GPS-501 L1, chokerings
NOV502		GPS-502 L1/L2
NOV502+CR		GPS-502 L1/L2, chokerings
NOV503+CR		GPS-503 L1/L2, chokerings
NOV503+CR	SPKE	GPS-503 L1/L2, chokerings,radome
NOV531		GPS-531 L1
NOV531+CR		GPS-531 L1, chokerings
NOV600		GPS-600 L1/L2
SEN67157514		L1/L2, P/N:S67-1575-14 (+26dB amp)
SEN67157514+CR		L1/L2, P/N:S67-1575-14, (+26dB amp), +cr
SEN67157549		L1, P/N:S67-1575-49
SEN67157549+CR		L1, P/N:S67-1575-49, +chokerings
SEN67157596		L1/L2, PN:S67-1575-96
SEN67157596+CR		L1/L2, PN:S67-1575-96, +chokerings
SOK_RADIAN_IS		Sokkia Radian IS
SOKA110		L1
SOKA120		L1/L2
SPP571212238+GP		groundplane
SPP571908273+CR		chokerings, oblong antenna element
SPP571908273+CR	SPKE	chokerings, oblong antenna element, +rd
TOP_LEGANT3_UHF		Legant 3 with UHF Antenna
TOP72110		D/M element (used with Turbo-SII)
TRM14532.00		4000ST L1/L2 Geodetic
TRM14532.10		4000SSE Kin L1/L2
TRM22020.00-GP		Geodetic L1/L2 compact -groundplane
TRM22020.00+GP		Geodetic L1/L2 compact +groundplane
TRM22020.00+GP		Geodetic L1/L2 compact +groundplane
TRM23903.00		Permanent L1/L2
TRM27947.00-GP		Rugged L1/L2 -groundplane
TRM27947.00+GP		Rugged L1/L2 +groundplane
TRM29659.00		D/M element, chokerings, -radome
TRM33429.00-GP		L1/L2 microcentered Compact Geodetic -GP
TRM33429.00+GP		L1/L2 microcentered Compact Geodetic +GP
TRM33429.00+GP		L1/L2 microcentered Compact Geodetic +GP
TRM33429.20+GP		L1/L2 microcentered Compact Geodetic +GP
TRM33429.20_NGS	UNAV	L1/L2 microcentered Compact Geodetic +GP
TRM36569.00+GP		13" microcentered +GP
TRM39105.00		Trimble Zephyr without Ground Plane
TRM41249.00		Trimble Zephyr Geodetic with GP

TRM4800 Receiver+Internal microcentered antenna

ANNEX N

GLOBAL POSITIONING SYSTEM DATA TRANSFER FORMAT (G-FILE)

This annex contains information about the Global Positioning System (GPS) Data Transfer Format (G-File) records. The G-File consists of eight 80-column record types that are used to document the results of the computation of relative vectors, expressed as components, from simultaneously observed GPS phase measurements. There may be only one G-file for a project. Each G-file must contain one Project Record (A) and one or more Session Header Records (B). A Session Header Record (B) is required for each individually processed vector or each simultaneously processed group of vectors (session) at three or more survey points. Each Session Header Record is followed by one or more Vector (C) and/or Long Vector (F) Records, Correlation (D) or Covariance (E) Records, optional Coordinate (G) Records, and optional and/or required Station Information (H) Records. Vector and Long Vector Records contain relative vector components between two survey points. Correlation Records contain the off-diagonal elements only of the correlation matrix for the vector components in a session. Covariance Records contain the off-diagonal elements only of the covariance matrix for the vector components in a session. The records for a simultaneously processed vector set may only contain correlation or covariance records but not a mix of the two. A Long Vector Record may only be used when a vector component is larger than +/- 999,999.9999 meters. The Coordinate (G) Records may be used to record, for informational purposes within the G-file, the coordinates of survey points held fixed during the vector computations or to provide location information regarding the G-file. Relative vectors are required even if coordinates are included. Station Information Records are used to document differing conditions or solution types for vectors within a session. The Station Information Record (H) is required only when an external time standard is used with a receiver, when a comment needs to be made about a station occupation, or when information about a station occupation or vector solution is not the same as for all other stations or vectors in a session. Multiple H records are allowed.

This annex documents the record formats, provides an explanation of the fields within each record, and gives G-file examples using the various record types.

CC-1 CODE	RECORD TYPE	
A	Project Record	(required)
B	Session Header Record	(required)
C	Vector Record	(required)
D	Correlation Record	(Either the D record or the
E	Covariance Record	(E record is required)
F	Long Vector Record	
G	Coordinate/Absolute Position Record (optional)	
H	Station Information Record	
I	Session Models Record (optional; follows the B record if used)	

Project Record

01-01	A		
02-03	Job Code (Chapter 1)		Alpha
04-07	Year, Start of Project (local)	(CCYY)	Integer
08-09	Month, Start of Project (local)	(MM)	Integer
10-11	Day, Start of Project (local)	(DD)	Integer
12-15	Year, End of Project (local)	(CCYY)	Integer
16-17	Month, End of Project (local)	(MM)	Integer
18-19	Day, End of Project (local)	(DD)	Integer
20-78	Title of project		Alpha
79-80	Reserved		

Session Header Record

01-01	B		
02-05	Year, First Actual Measurement (UTC)	(CCYY)	Integer
06-07	Month, First Actual Measurement (UTC)	(MM)	Integer
08-09	Day, First Actual Measurement (UTC)	(DD)	Integer
10-13	Time, First Actual Measurement (UTC)	(HHMM)	Integer
14-17	Year, Last Actual Measurement (UTC)	(CCYY)	Integer
18-19	Month, Last Actual Measurement (UTC)	(MM)	Integer
20-21	Day, Last Actual Measurement (UTC)	(DD)	Integer
22-25	Time, Last Actual Measurement (UTC)	(HHMM)	Integer
26-27	Number of Vectors in the Session		Integer
28-42	Software Name & Version		Alpha
43-47	Orbit Source (agency that computes orbit)		Alpha
48-51	Orbit accuracy estimate (XX.xx meters)		Implied Decimal
52-53	Solution coordinate system code	(table, N-6)	Integer
54-55	Solution meteorological use code	(table, N-6)	Integer
56-57	Solution ionosphere use code	(table, N-6)	Integer
58-59	Solution time parameter use code	(table, N-6)	Integer
60-60	Nominal accuracy code	(table, N-8)	Integer
61-66	Processing agency code	(Annex C)	Alpha
67-70	Year of Processing	(CCYY)	Integer
71-72	Month of processing	(MM)	Integer
73-74	Day of processing	(DD)	Integer
75-80	Solution Type	(table, N-7)	Alpha

Note: Columns 43 through 47 of Record B contain the symbol of the agency which computes and provides GPS satellite orbit information. Columns 61 through 66 contain the symbol of the agency that does the observation reduction processing. Columns 52 through 80 of Record B assume all stations use identical observing and computation procedures. If this is not the case, use Record H to record the differences for each station which varies from those conditions noted on the B record.

Note: If the number of vectors in a session exceeds 99, leave columns 26 through 27 blank. In such cases, the number of vectors can be determined by counting the "C" records or the "F" records.

Vector Record

```
01-01  C
02-05  Origin Station Serial Number (ssn)  (vector tail)  Integer
06-09  Differential Station Serial Number  (vector head)  Integer
10-20  Delta X            (XXXXXXX.xxxx meters)   Implied Decimal
21-25  Standard Deviation (X.xxxx meters)         Implied Decimal
26-36  Delta Y            (XXXXXXX.xxxx meters)   Implied Decimal
37-41  Standard Deviation (X.xxxx meters)         Implied Decimal
42-52  Delta Z            (XXXXXXX.xxxx meters)   Implied Decimal
53-57  Standard Deviation (X.xxxx meters)         Implied Decimal
58-58  Rejection Code (use upper case R to reject)        Alpha
59-68  Origin Station Data Media Identifier       (See page N-6)
69-78  Differential Station Data Media Identifier (See page N-6)
79-80  Reserved
```

Note: Standard deviation values must be positive, non-zero numbers.

Correlation Record

```
01-01  D
02-04  Row Index Number                                   Integer
05-07  Column Index Number                                Integer
08-16  Correlation         (XX.xxxxxxx)           Implied Decimal
17-19  Row Index Number                                   Integer
20-22  Column Index Number                                Integer
23-31  Correlation         (XX.xxxxxxx)           Implied Decimal
32-34  Row Index Number                                   Integer
35-37  Column Index Number                                Integer
38-46  Correlation         (XX.xxxxxxx)           Implied Decimal
47-49  Row Index Number                                   Integer
50-52  Column Index Number                                Integer
53-61  Correlation         (XX.xxxxxxx)           Implied Decimal
62-64  Row Index Number                                   Integer
65-67  Column Index Number                                Integer
68-76  Correlation         (XX.xxxxxxx)           Implied Decimal
77-80  Reserved
```

Note: This record is to record the off-diagonal correlates only from the session (or vector) correlation matrix. Since the correlation matrix is symmetric about the diagonal, only the upper or the lower half should be recorded.

Covariance Record

01-01	E	
02-04	Row Index Number	Integer
05-07	Column Index Number	Integer
08-19	Covariance (XXXX.xxxxxxxx meters^2)	Implied Decimal
20-22	Row Index Number	Integer
23-25	Column Index Number	Integer
26-37	Covariance (XXXX.xxxxxxxx meters^2)	Implied Decimal
38-40	Row Index Number	Integer
41-43	Column Index Number	Integer
44-55	Covariance (XXXX.xxxxxxxx meters^2)	Implied Decimal
56-58	Row Index Number	Integer
59-61	Column Index Number	Integer
62-73	Covariance (XXXX.xxxxxxxx meters^2)	Implied Decimal
74-80	Reserved	

Note: This record is to record the off-diagonal covariances only from the vector variance-covariance matrix. The square root of the diagonal elements, the component standard deviations, are recorded on records C and F. Since the variance-covariance matrix is symmetric about the diagonal, only the upper or the lower half should be recorded.

Long Vector Record

01-01	F	
02-05	Origin Station Serial Number (ssn) (vector tail)	Integer
06-09	Differential Station Serial Number (vector head)	Integer
10-22	Delta X (XXXXXXXXX.xxxx meters)	Implied Decimal
23-27	Standard Deviation (X.xxxx meters)	Implied Decimal
28-40	Delta Y (XXXXXXXXX.xxxx meters)	Implied Decimal
41-45	Standard Deviation (X.xxxx meters)	Implied Decimal
46-58	Delta Z (XXXXXXXXX.xxxx meters)	Implied Decimal
59-63	Standard Deviation (X.xxxx meters)	Implied Decimal
64-64	Rejection Code (use upper case R to reject)	Alpha
65-65	Origin station manufacturer code	(N-6)
66-68	Origin station UTC day of year of occupation (DDD)	Integer
69-69	Origin station year of occupation (Y) UTC	Integer
70-70	Origin station session indicator	Alpha
71-71	Differential station manufacturer code	(N-6)
72-74	Differential station day of year (DDD) UTC	Integer
75-75	Differential station year of occupation (Y) UTC	Integer
76-76	Differential station session indicator	Alpha
77-80	Reserved	

Note: Standard deviation values must be positive, non-zero numbers.

Coordinate Record

```
01-01  G
02-02  Blank
03-03  Record usage code K - see below
04-05  Blank
06-09  Station Serial Number
10-10  Blank
11-14  Optional 4-character ID or "short" station name - see below
15-15  Blank
16-20  Coordinate frame designator (e.g. NAD 83, WGS 84, NAD 27,
        WGS 72, ITR 90, etc.; inquire for additions)
21-21  Blank
22-33  X coordinate (XXXXXXXX.xxxx meters)        Implied Decimal
34-34  Blank
35-46  Y coordinate (YYYYYYYY.yyyy meters)        Implied Decimal
47-47  Blank
48-59  Z coordinate (ZZZZZZZZ.zzzz meters)        Implied Decimal
60-60  Blank
61-64  Sigma X (SS.ss m) blank if unknown or greater than 99.99 m
65-65  Blank
66-69  Sigma Y (SS.ss m) blank if unknown or greater than 99.99 m
70-70  Blank
71-74  Sigma Z (SS.ss m) blank if unknown or greater than 99.99 m
75-80  Reserved
```

K = 0 or blank indicates that the position is approximate and has no particular interpretation.
K = 1 indicates that these are exact coordinates (to 0.1 mm) used during the processing of the G-file vectors.

The 4-character ID or "short" name, if used in cc 11-14, should be the same abbreviation used elsewhere in the G-file (Data Media Identifier) and in other related data files (for example, the *25* records of the B file).

Station Information Record

```
01-01  H
02-05  Station Serial Number (ssn)                          Integer
06-09  Four Character Identifier                            Alpha
10-11  External frequency standard code (table, N-8)
12-13  Vector meteorological use code   (table, N-6)
14-15  Vector time parameter use code   (table, N-6)
16-17  Vector ionosphere use code       (table, N-6)
18-23  Vector Solution type             (table, N-7)
24-78  Comments                                             Alpha
79-80  Reserved
```

Use comment field to record clarifying information or instrument type if noted as "other" in Data Media Identifier.

Session Model Record

```
01-01  I
02-13  Name of Antenna Pattern File
14-21  Reserved
22-27  Agency/Source of Antenna Pattern File (From Annex C)
28-35  Version/Date for Antenna Pattern File (YYYYMMDD)
36-80  Blank
```

CODE TABLES

Solution Coordinate Reference System Codes

01 -- WGS 72 Precise Ephemeris [DMA] Used from GPS beginning through 1/3/87
02 -- WGS 84 Precise Ephemeris [DMA] from 1/4/87 through 1/1/94
03 -- WGS 72 Broadcast Ephemeris [DOD] from GPS beginning through 1/22/87
04 -- WGS 84 Broadcast Ephemeris [DOD] from 1/23/87 through 6/28/94
05 -- ITRF 89 Epoch 1988.0 (International Earth Rotation Service
NOT USED AS A GPS REFERENCE FRAME
06 -- NEOS 91.25 Epoch 1988 [NGS] from Spring 1991 through 10/19/91
SPECIAL VLBI COORDINATE SOLUTION written by Mike Abell
07 -- NEOS 90 Epoch 1988.0 [NGS] from 10/20/91 through 8/15/92
08 -- ITRF 91 Epoch 1988.0 [NGS] from 8/16/92 through 12/19/92
09 -- SIO/MIT 1992.57 Epoch 1992.57 [NGS] from 12/20/92 through 11/30/93
10 -- ITRF 91 Epoch 1992.6 [NGS] from 12/1/93 through 1/8/94
11 -- ITRF 92 Epoch 1994.0 [NGS] from 1/9/94 through 12/31/95
12 -- ITRF 93 Epoch 1995.0 [NGS] from 1/1/95 through 6/29/96
13 -- WGS 84 (G730) Epoch 1994.0 [DMA] from 1/2/94 through 9/28/96
14 -- WGS 84 (G730) Epoch 1994.0 Broadcast [DOD USAF] from 6/29/94 through 1/28/97
15 -- ITRF 94 Epoch 1996.0 [NGS] from 6/30/96 through 2/28/98
16 -- WGS 84 (G873) Epoch 1997.0 [NIMA] (formerly DMA) from 9/29/96 to 1/19/2002
17 -- WGS 84 (G873) Epoch 1997.0 Broadcast [DOD USAF] from 1/29/97 to 1/19/2002
18 -- ITRF 96 Epoch 1997.0 [NGS] from 3/1/98 through 7/31/99
19 -- ITRF 97 Epoch 1997.0 [NGS] from 8/1/1999 through 6/3/2000
20 –- IGS 97 Epoch 1997.0 [NGS] from 6/4/2000 through 12/1/2001
21 –- ITRF 00 Epoch 1997.0
22 –- IGS 00 Epoch 1998.0 [NGS] from 12/2/2001 through 1/10/2004
23 –- WGS 84 (G1150) Epoch 2001.0 [NIMA] from 1/20/2002 to the present
24 -- IGb 00 Epoch 1998.0 [NGS] from 0000 UTC 1/11/2004 to 11/4/2006
25 -- ITRF 2005 [ITRF 05] (epoch 2000.0) not used as a reference frame
26 -- IGS 05 Epoch 2000.0 [NGS] from 0000 UTC 11/5/2006 through 4/16/2011
27 -- IGS 08 Epoch 2005.0 used by NGS from 0000 UTC 4/17/2011 until 2400 UTC 10/6/2012
28 -- IGb 08 Epoch 2005.0 used by NGS from 0000 UTC 10/7/2012 until the present.

Solution Meteorological Use Codes

01 -- Default values used (model used)
02 -- Observed meteorological data used
03 -- Water vapor radiometer used

Solution Ionosphere Use Code

01 -- None
02 -- Dual frequency ionospheric correction used
03 -- Ionospheric model used

Solution Time Parameter Use Codes

01 -- Observed time synchronization data used
02 -- Time parameters solved for in data reduction

Data Media Identifier

Required format: ADDDYSCCCC where
A is one of the following characters which indicates the manufacturer of the receiver used for the observation: A = Ashtech, Inc; C = Topcon Corp; D = Del Norte Technology, Inc; E = Magellan; G = Allen Osborne; I = Istac; J = Javad Position Systems; K = Sokkia; L = MINI-MAC®; M = Macrometer®; N = Norstar Instruments; O = Motorola, Inc; P = Spectra Precision; Q = 3S Navigation; R = Trimble Navigation Ltd.; S = SERCEL, Inc; T = Texas Instruments; V = NovAtel Communications Ltd; W = Wild, Leica, Magnavox; X = other

Data Media Identifier (cont)

DDD is the day of the year of the first data epoch (UTC)
Y is the last digit of the year of the first data epoch (UTC)
S is an alphanumeric designation of the session
CCCC is the project-unique, four-character ID or abbreviation of a station designation used to cross-reference station occupations between the B and G file

CODE TABLES (continued)

Solution Type Use Codes

+ L1TD--	L1SDFL	L1DDFL	IFDDFL	OTDDFL	K1DDFX
+ L2TD--	L1SDFX	L1DDFX	IFDDFX	OTDDFX	K2DDFX
+ IFTD--	L1SDPF	L1DDPF	IFDDPF	OTDDPF	KIDDFX
+ WLTD--					KWDDFX
		L2DDFL	WLDDFL		P1DDFX
		L2DDFX	WLDDFX		P2DDFX
		L2DDPF	WLDDPF		PIDDFX
					PWDDFX

Where: L1 = Frequency 1
L2 = Frequency 2
IF = Ionosphere Free Combination (Static) *
WL = Wide Lane Combination (Static or Rapid Static)**
OT = Other (Explain in Station Information Record)

K1 = L1 Kinematic Observation (Single visit, continuous lock - also known as Continuous Kinematic, Stop and Go Kinematic, or On-the-Fly Kinematic)
K2 = L2 Kinematic
KI = Ionosphere Free Combination Kinematic *
KW = Wide Lane Combination Kinematic **

P1 = L1 Pseudo-kinematic (Two or more visits, intermittent lock - also known as Pseudo-static, Intermittent Static or Reoccupation techniques)
P2 = L2 Pseudo-kinematic
PI = Ionosphere Free Combination Pseudo-kinematic *
PW = Wide Lane Combination Pseudo-kinematic **

TD = Triple Difference Solution
DD = Double Difference Solution
SD = Single Difference Solution

FL = Float (real number) estimate of biases
FX = Fixed integer estimate of biases
PF = Partial, fixed integer estimate of biases (Not all integer biases determinable).

\+ Triple Difference Solutions have no integer ambiguities, leave trailing columns blank.
* IF = ionosphere free = $\{f^2_1/(f^2_1 - f^2_2)\}L_1 - \{f_1 f_2/(f^2_1 - f^2_2)\}L_2$
** WL = wide lane = L1 - L2

Where f_1 = 1575.42 mHz, f_2 = 1227.60 mHz, and L_1 and L_2 are phase measurements in units of cycles.

CODE TABLES (continued)

External Frequency Standard

01 -- No external frequency standard used
02 -- Rubidium frequency standard used
03 -- Cesium frequency standard used
04 -- Hydrogen Maser frequency standard used
05 -- External crystal frequency standard used
06 -- Other (Comment in Station Information Record)

Vector Nominal Accuracy Codes

Code	Intended accuracy	Order/Class
4 --	Intended accuracy 100 ppm plus 5.0 cm	3
3 --	Intended accuracy 50 ppm plus 3.0 cm	2-II
2 --	Intended accuracy 20 ppm plus 2.0 cm	2-I
5 --	Intended accuracy 10 ppm plus 1.0 cm	1
6 --	Intended accuracy 1 ppm plus 0.8 cm	B
7 --	Intended accuracy 0.1 ppm plus 0.5 cm	A
8 --	Intended accuracy 0.01 ppm plus 0.3 cm	AA

G-FILE EXAMPLES

Below are fragments from six independent, simulated GPS Data Transfer Format files (G-FILEs). There is one Project record (A) per G-file. Each session vector set, or individually computed vector in a multi-receiver session, requires a Session Record (B). Each vector requires at least one Vector Record (C) or Long Vector Record (F). Vector Records with Coordinate Records must follow the same Session Record. Station Information (H) Records are required as circumstances dictate and may be optionally added where not required. These records must be followed by sufficient Correlation (D) or Covariance Records (E) to express all off-diagonal correlation or covariance terms in the matrix half provided from the session computation. Correlation and Covariance Records may not be intermixed.

1. Project (A), Session (B), Vector (C), and Correlation (D) records for a single vector between two stations in a two receiver session or individually computed vector in a multi-receiver session.

```
AKS1989061619890810
B198906222104198906230032010MNI21JUL89    BDCST200040101025NGS    19890919L1DDFX
C02860255   22818804  691  517712752 1665  621497962 1259 M1739APACIM1739AK60A
D  1  2 -1507832  1  3 -1653265  2  3 -9400487
```

2. Project (A), Session (B), Vector (C), and Correlation (D) records for a three-receiver (two vector) session computed simultaneously in session mode.

```
AA21989061619890810
B1989071919201989071920220 20MNI21JUL89    NSWC  200020202026NGS   19891010IFDDFL
C02520251    2090836   21    3595939   80    5412122   45 T1735BTOLPT1735BIO35
C02520250  -42878920   42  -19024426   93  -28455946   69 T1735BTOLP71735BIO17
D  1  2 -3449463  1  3  -169254  1  4 -7443040  1  5 -3452654  1  6  1753975
D  2  3 -7698120  2  4 -6329835  2  5  1258498  2  6  8573493  3  4 -6485385
D  3  5 -6084380  3  6  -477478  4  5 -6124087  4  6 -3864367  5  6  8630812
```

Note: If a multi-receiver session is computed as if all possible vectors are independent, then there would be Session, Vector, and Correlation records for each vector in the session. Thus, the record sequence would be A, B, C, D, B, C, D, B, C, D, etc. The Session records would be nearly identical to the multi-receiver example except that start and stop times could vary with each vector. The number of vectors indicated on each Session Record would be one, i.e., there would be a Session Record for each vector and the cross correlation terms between vectors would not exist.

3. Project (A), Session (B), Vector (C), and Correlation (D) Records for a five-receiver (four vector) session computed simultaneously in session mode.

```
AW11989061619890810
B19890718192419890718225204OMNI21JUL89    BDCST 200020202025NGS   19891003L1DDFL
C03000287    5764741   77    1459095   44    2345097   54 R1765ASMILR1765ANEOP
C03000223  -52521873   47    -229406  101   -1142670   75 R1765ASMILR1765ACESZ
C03000305  -42878920   42  -19024426   93  -28455945   69 R1765ASMILR1765AX042
C03000240    7097171   69   -1171456   40   -1443438   46 R1765ASMILR1765AG042
D  1  2 -7621157  1  3 -6268111  1  4  1032188  1  5 -7397468  1  6  2749723
D  1  7 -7716473  1  8 -6339150  1  9  1294594  1 10 -2396473  1 11 -2753742
D  1 12 -5804898  2  3  -791184  2  4 -6108347  2  5 -1739462  2  6  9010327
D  2  7 -7729301  2  8 -6463718  2  9  1526641  2 10 -3826492  2 11  3610736
D  2 12 -6449538  3  4   170894  3  5 -6299216  3  6 -1003847  3  7 -5307149
D  3  8 -7680811  3  9 -6477668  3 10  1506536  3 11 -9537262  3 12 -1836426
D  4  5 -6154878  4  6  -248020  4  7 -6087715  4  8 -1633847  4  9  6354725
D  4 10 -7804602  4 11 -6047825  4 12  1262026  5  6  3746287  5  7 -7243634
D  5  8 -6110139  5  9  -321344  5 10 -6165227  5 11  8362528  5 12  9162533
D  6  7 -5971690  6  8  -516393  6  9 -6136978  6 10 -9354622  6 11  1535474
D  6 12 -5920223  7  8  -559594  7  9 -6153794  7 10  2645373  7 11 -5373742
D  7 12 -5527744  8  9 -7793107  8 10  1043462  8 11  5378213  8 12 -2564522
D  9 10 -5371777  9 11 -7908942  9 12  1046883 10 11  8354256 10 12 -3372634
D 11 12  7153372
```

4. Project (A), Session (B), Vector (C), and Covariance (E) Records for a three-receiver (two vector) session computed simultaneously in session mode.

```
AC51989061619890810
B19890719192019890719202202OMNI21JUL89    NSWC  200020202026NGS   19891010WLDDPF
C02520251    2090836   21    3595939   80    5412122   45 T1735BTOLPT1735BIO35
C02520250  -42878920   42  -19024426   93  -28455946   69 T1735BTOLPT1735BIO17
E  1  2    -3449231  1  3      169013  1  4    -7443219  1  5    -3452017
E  1  6    -1753648  2  3     7698884  2  4    -6329438  2  5     1258689
E  2  6     8573027  3  4    -6485903  3  5    -6084227  3  6     -477369
E  4  5     6124824  4  6    -3864711  5  6     8630682
```

5. Project (A), Session (B), Long Vector (F), and Correlation (D) Records for a three-receiver (two vector) session computed simultaneously in session mode.

```
AM31989061619890810
B19900312192019900312202203OMNI21JUL89    NSWC  200050202027NGS  19900605IFDDPF
F02520251  -7398138095   62   -611028070  140   -759539795   81 R0710AR0710A
F02520210 -28097365450    2   6537703840    2   1612488880    2 R0710AR0710A
D  1  2 -3449463  1  3  -169254  1  4 -7443040  1  5 -3452654  1  6  1753975
D  2  3 -7698120  2  4 -6329835  2  5  1258498  2  6  8573493  3  4 -6485385
D  3  5 -6084380  3  6  -477478  4  5 -6124087  4  6 -3864367  5  6  8630812
```

6. Project (A), Session (B), Vector (C), Coordinate (G), Station Information (H), and Correlation (D) Records for a five-receiver session computed simultaneously.

```
AG41989061619890810
B19921019162019921019202204OMNI06JAN93    NGS    50090202027NGS   19930115IFDDFX
C02520251 -121666909   30  157350726   56  117976050   41 R2932ANORDR2932ASECO
C02520250 -418472429   32  247232117   60    8372071   44 R2932ANORDR2932ABURR
C02520253 -553950607   35  500052515   64  221106176   48 R2932ANORDR2932AFIGU
C02520254 -289152973   31  300310186   55  183697838   42 R2932ANORDR2932APINE
G 1  0252 NORD SIO92 -25711011350 -45925184360  35928923390  010  010  010
H0252NORD01020202IFDDFXREFERENCE STATION
D  1  2 -7621157  1  3 -6268111  1  4  1032188  1  5 -7397468  1  6  2749723
D  1  7 -7716473  1  8 -6339150  1  9  1294594  1 10 -2396473  1 11 -2753742
D  1 12 -5804898  2  3  -791184  2  4 -6108347  2  5 -1739462  2  6  9010327
D  2  7 -7729301  2  8 -6463718  2  9  1526641  2 10 -3826492  2 11  3610736
D  2 12 -6449538  3  4   170894  3  5 -6299216  3  6 -1003847  3  7 -5307149
D  3  8 -7680811  3  9 -6477668  3 10  1506536  3 11 -9537262  3 12 -1836426
D  4  5 -6154878  4  6  -248020  4  7 -6087715  4  8 -1633847  4  9  6354725
D  4 10 -7804602  4 11 -6047825  4 12  1262026  5  6  3746287  5  7 -7243634
D  5  8 -6110139  5  9  -321344  5 10 -6165227  5 11  8362528  5 12  9162533
D  6  7 -5971690  6  8  -516393  6  9 -6136978  6 10 -9354622  6 11  1535474
D  6 12 -5920223  7  8  -559594  7  9 -6153794  7 10  2645373  7 11 -5373742
D  7 12 -5527744  8  9 -7793107  8 10  1043462  8 11  5378213  8 12 -2564522
D  9 10 -5371777  9 11 -7908942  9 12  1046883 10 11  8354256 10 12 -3372634
D 11 12  7153372
```

ANNEX O

GRAVITY CONTROL FORMULAS
DEPARTMENT OF DEFENSE GRAVITY LIBRARY

Formulas Used in Computing Free-Air and Bouguer Anomalies

1. Symbology

Symbol	Definition	Units
g	Free-Air Anomaly	milligals
g	Bouguer Anomaly	milligals
ϕ	Latitude of Observation	degrees, minutes
γ	Theoretical Gravity	milligals
g	Observed Gravity	milligals
h	Elevation (Col 23-29) of surface of land, ice or water; depth of ocean, (positive downward) elevation types 3, 4, and 5. + = above SL; - = below SL.	meters
d	Supplemental Elevation (Col 31-35) = Depth of Ocean, lake, ice or instrument (positive downward)	meters

2. Theoretical Gravity Computation

Using the International Gravity Formula 1967

$$\gamma = C_1 (1 + C_2 \sin^2 \phi + C_3 \sin^4 \phi)$$

where: $C_1 = 978031.85$ mgals

$C_2 = 0.0052788 95$

$C_3 = 0.000\ 023462$

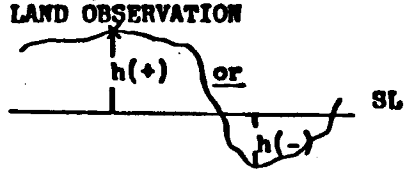
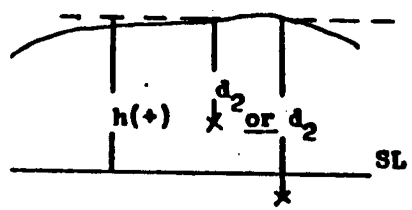
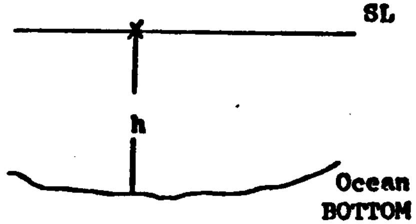
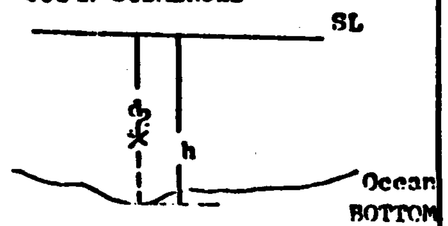
3. **Anomaly Computations**

b = Bouguer Correction Factor
= $2\pi\kappa\rho = 0.04191\rho$

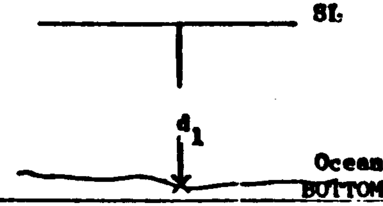
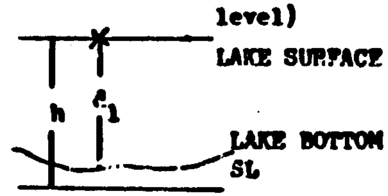
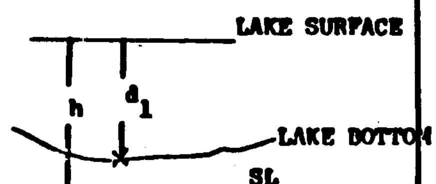
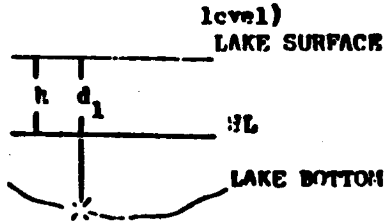
ρ = Density Used in Computations

Substance	ρ	$b = 2\pi\kappa\rho$
Fresh Water	1.0	0.04191
Salt Water	1.027	0.04304
Ice	0.917	0.03843
Land	2.67	0.1119
Land-Fresh Water	1.67	0.06999
Land-Salt Water	1.643	0.06886
Land and Ice	1.753	0.07347

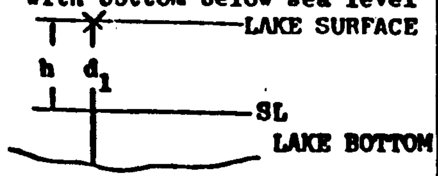
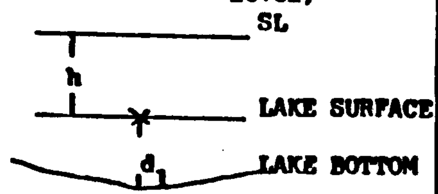
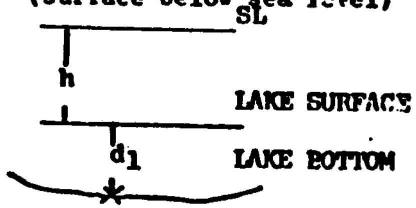
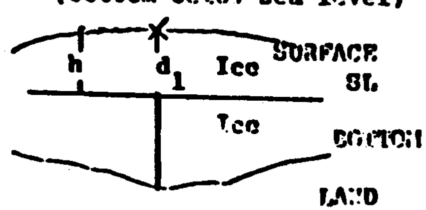
ANOMALY COMPUTATION CHART (p. 1)

Elev. Type Col.21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
1	LAND OBSERVATION 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.1119h$
2	SUBSURFACE 	$\Delta g_f = g + 0.2238d_2 + 0.3086(h-d_2) - \gamma$ NOTE: d_2 = depth of instrument	$\Delta g_B = \Delta g_f - 0.1119h$
3	OCEAN SURFACE 	$\Delta g_f = g - \gamma$	$\Delta g_B = \Delta g_f + 0.06886h$ NOTE: h = depth of ocean positive downward from surface
4	OCEAN SUBMERGED 	$\Delta g_f = g - 0.2225d_2 - \gamma$ NOTE: d_2 = depth of instrument positive downward	$\Delta g_B = \Delta g_f + 0.06886h$ NOTE: h = depth of ocean positive downward

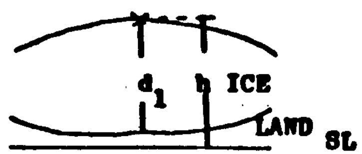
ANOMALY COMPUTATION CHART (p. 2)

Elev. Type Col.21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
5	OCEAN BOTTOM 	$\Delta g_f = g - 0.2225d_1 - \gamma$ NOTE: d_1 = depth of ocean positive downward	$\Delta g_B = \Delta g_f + 0.06886d_1$
6	LAKE SURFACE (above sea level) 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.04191d_1 - 0.1119(h-d_1)$ NOTE: d_1 = depth of lake positive downward
7	LAKE BOTTOM (above sea level) 	$\Delta g_f = g + 0.08382d_1 + 0.3086(h-d_1)-\gamma$	$\Delta g_B = \Delta g_f - 0.04191d_1 - 0.1119(h-d_1)$
8	LAKE BOTTOM (below sea level) 	$\Delta g_f = g + 0.08382d_1 + 0.3086(h-d_1)-\gamma$	$\Delta g_B = \Delta g_f - 0.04191h - 0.06999(h-d_1)$

ANOMALY COMPUTATION CHART (p. 3)

Elev. Type Col. 21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
9	LAKE SURFACE (above sea level) with bottom below sea level 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.04191h - 0.06999(h-d_1)$
A	LAKE SURFACE (below sea level) 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.1119h + 0.06999d_1$ <u>NOTE:</u> d_1 = depth of lake positive downward
B	LAKE BOTTOM (surface below sea level) 	$\Delta g_f = g + 0.3086h - 0.2248d_1 - \gamma$ <u>NOTE:</u> d_1 = depth of lake positive downward	$\Delta g_B = \Delta g_f - 0.1119h + 0.06999d_1$
C	ICE CAP (bottom below sea level) 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.03843h - 0.07347(h-d_1)$ <u>NOTE:</u> d_1 = depth of ice positive downward

ANOMALY COMPUTATION CHART (p. 4)

Elev. Type Col.21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
D	ICE CAP (bottom above sea level) 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.03843d_1 - 0.1119(h-d_1)$ **NOTE:** d_1 = depth of ice

Input Formats and Specifications of the National Geodetic Survey Data Base

Volume III. Gravity Control Data

Silver Spring, MD 20910
September 1994

Reprinted December 1997 with Updates to:

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          Annex A      (See Volume I)
                C
                F
                I
                K
                N
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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Coast and Geodetic Survey

September 1994

POLICY OF THE NATIONAL OCEAN SERVICE REGARDING THE INCORPORATION OF GEODETIC DATA OF OTHER ORGANIZATIONS INTO THE NATIONAL GEODETIC SURVEY DATA BASE

The National Ocean Service (NOS), Coast and Geodetic Survey, National Geodetic Survey (NGS), has determined that the value to the National Spatial Reference System (NSRS) of geodetic observations obtained by other Federal, state, and local organizations compensates for the costs incurred by the Federal Government to provide quality assurance, archiving, and distribution functions for surveys contributing to the public good. Agencies submitting data must adhere to the following requirements. The final decision whether to accept data will be the responsibility of the Chief, NGS.

FORMAT

The survey data must be submitted in the automated formats specified in the Federal Geographic Data Committee (FGDC), Federal Geodetic Control Subcommittee (FGCS), publication Input Formats and Specifications of the National Geodetic Survey Data Base (September 1994), which describes the formats and procedures of submitting data for adjustment and assimilation into the NGS data base. Separate volumes of this publication refer to horizontal control data (volume I), vertical control data (volume II), and gravity control data (volume III). Guidelines for submitting three-dimensional Global Positioning System (GPS) relative positioning data are contained in Annex L of volume I.

ACCURACY

Standards of accuracy are given in Standards and Specifications for Geodetic Control Networks (1984) and Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques (May 1988).

The survey data must be properly formatted as set forth by FGCS and meet the minimum accuracy requirements of:

First-order horizontal accuracy standards for GPS or conventional horizontal surveys.

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

Third-order gravity accuracy standards for gravity surveys.

In addition, these data standards and accuracies must be verified, using currently available NGS software, by the provider prior to submitting the survey project to NGS.

Please note: Effective September 1, 1995, survey project data must meet the above minimum accuracy standards to be accepted for inclusion in 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.

MONUMENTATION

Monumentation must be uniquely identified and conform to minimum prescribed standards. Guidelines for control monuments are given in <u>NOAA Manual</u> NOS NGS 1 (1978), Coast and Geodetic Survey <u>Special Publication</u> 247 (1950), and in <u>Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques</u>, appendix H (May 1988). Monument descriptions must be submitted in the automated format specified in <u>Input Formats and Specifications of the National Geodetic Survey Data Base</u> (September 1994).

FIELD RECORDS

Original field records (or acceptable copies) are requested with data submission. NGS will retain these records in the National Archives and Records Administration. This is necessary in the event that questions arise concerning the surveys upon which the adjusted data are based. Where digital records are required, e.g., GPS projects, such records will be submitted to NGS in a format specified by NGS at the time of submission. If field records are not submitted with the data, NGS reserves the right to inspect these records upon request. If field records are not submitted on request, NGS reserves the right to not accept and/or not publish the data, and if published, a disclaimer may be attached to the published data.

PROJECT REPORT

A project report, including sketches, is required for geodetic control projects. It should be submitted with the data and adhere to the form outlined in annexes K and L (GPS) of <u>Input Formats and Specifications of the National Geodetic Survey Data Base</u> (September 1994).

REVIEW

Reconnaissance reports describing proposed connections to the NSRS, along with the planned instrumentation and field procedures, must be submitted prior to beginning a project. This will enable NGS to comment on the proposed connections, using information available in the NGS data base concerning the accuracy and condition of these points, and to assure conformance with minimum accuracy standards and criteria. The project review could save the submitting agency the expense of placing data in computer-readable form that will fail accuracy or monumentation criteria. NGS work schedules and computer requirements can also be developed from this information. Upon receipt of the reconnaissance reports, NGS will respond within 10 working days.

RETURNED SUBMISSIONS

With verbal concurrence of the submitting organization, a limited number of errors in the submitted data will be corrected by NGS. Beyond a reasonable limit of about 1 percent, the entire project will be returned to the sender.

SUBMITTED PROJECTS

Projects must be submitted such that the unit of field work will compute independently of other projects. They must be connected to points already in the NGS data base. All data pertaining to a project (observations, descriptions, adjustments, reports, etc.) must be simultaneously received by NGS. Due to a limited capability to review, analyze, and edit survey data before they are loaded into the NGS data base, data contributed for inclusion into the data base should be processed and adjusted by the provider, using currently available NGS software, prior to submittal to NGS.

COST

There is no cost to submitters for NGS quality review, archiving, and distribution functions for survey data submitted according to the requirements discussed above. When NGS is requested to provide on-site instruction with respect to data formatting and/or data processing, the requesting organization will be charged for travel and per diem costs.

PUBLICATIONS

All the publications referenced in this statement are available from the National Geodetic Information Branch, N/CG174, NOAA, 1315 East-West Highway, Silver Spring, MD 20910-3282.

Telephone (301) 713-3242   Fax (301) 713-4172

PREFACE

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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.

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

NOAA, National Geodetic Survey, N/NGS12
1315 East-West Highway, Station 9202
Silver Spring, MD 20910-3282
Telephone: (301) 713-3242; Fax: (301) 713-4172
Monday through Friday, 7:00 a.m. - 4:30 p.m. Eastern Time.

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Chapter 9 - GRAVITY CONTROL (GRAV) DATA

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ANNEX I - SUMMARY OF CODES IN GEODETIC SURVEY POINT DESCRIPTIONS - See Vol I

ANNEX J - SUMMARY OF CODES USED IN BM DESC - superseded by Vol I, Annex I

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Input Formats and Specifications of the National Geodetic Survey Data Base

Volume I. Horizontal Control Data

Charles W. Challstrom, NOAA
Chairperson, Federal Geodetic Control Subcommittee
Federal Geodetic Data Committee

Silver Spring, MD
March, 2003

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

National Ocean Service

National Geodetic Survey

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 is distributed on the Internet at http://www.ngs.noaa.gov/FGCS/BlueBook. It comprises three volumes and several Annexes. Volume I covers classical horizontal geodetic and Global Positioning System (GPS) data, volume II covers vertical geodetic data, and volume III covers gravity data.

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.

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

Third-order gravity standards for gravity surveys.

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In addition, these data standards and accuracies must be verified and the survey data contributed for inclusion into the NGS data base must 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.

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Chapter 2 - HORIZONTAL OBSERVATION (HZTL OBS) DATA

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THE FOLLOWING ANNEXES ARE AVAILABLE AS LINKS FROM THE WEBSITE
http://www.ngs.noaa.gov/FGCS/BlueBook/:

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ANNEX C - CONTRIBUTORS OF GEODETIC CONTROL DATA

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ANNEX K - PROJECT REPORT INSTRUCTIONS

ANNEX L - GUIDELINES FOR SUBMITTING GPS RELATIVE POSITIONING DATA

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Input Formats and Specifications of the National Geodetic Survey Data Base

Volume II. Vertical Control Data

Charles W. Challstrom, NOAA
Chairperson, Federal Geodetic Control Subcommittee
Federal Geodetic Data Committee

Silver Spring, MD
September 1994

Reprinted
November 1998

(See Volume I for Annex A through Annex N)

U.S. DEPARTMENT OF COMMERCE
William M. Daley, Secretary

National Oceanic and Atmospheric Administration
Dr. D. James Baker, Administrator

National Ocean Service
Dr. Nancy Foster

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Chapter 7 - VERTICAL DESCRIPTIVE (VERT DESC) DATA - see Vol I, Chapter 3

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ANNEX L - GUIDELINES FOR SUBMITTING GPS RELATIVE POSITIONING DATA - see Vol I

ANNEX N - GLOBAL POSITIONING SYSTEM DATA TRANSFER FORMAT - see Vol I

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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