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

<table>
<tr><td colspan="2">Data Set Identification Record</td></tr>
<tr><td>*10* record
...
...
*86 record</td><td>First Project</td></tr>
<tr><td>*10* record
...
...
*86 record</td><td>Second Project</td></tr>
<tr><td>...
...</td><td>...
...</td></tr>
<tr><td>*10* record
...
...
*86 record</td><td>Last Project</td></tr>
<tr><td colspan="2">Data Set Termination Record</td></tr>
</table>

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:

<u>Project Data (*10*-Series) Records</u>:

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

<u>Horizontal Direction Data (*20*-Series) Records</u>:

```
*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
```

<u>Global Positioning Systems Data (*20*-Series) Records</u>:

```
*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)

<u>Horizontal Angle Data (*30*-Series) Records</u>:

```
*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
```

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

```
*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
```

<u>Distance Data (*50*-Series) Records</u>:

```
*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 <u>ACCURACY OF THE OBSERVATIONS</u>.

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.

<u>Standpoint and Forepoint</u>: 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."

<u>Station Serial Number</u>: 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 <u>ASSIGNMENT OF STATION SERIAL NUMBERS</u>, 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. 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.

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").

Method A: The eccentric observations are to be reduced to center. 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.

Method B: The eccentric point is to be treated as a control point 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.

Number of Replications: 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).

Rejection Limit: 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.

Set Number: 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.

Number of Objects Sighted in This Set: 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.

Date and Time: 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.

GLOBAL POSITIONING SYSTEM DATA RECORDS

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 OBSERVATION DATA RECORDS, p. 2-8 ff. Other GPS record entries are self-explanatory.

Job-Specific Data Media Data Identifier: 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.

HORIZONTAL ANGLE DATA RECORDS

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 one determination of that angle (i.e., one 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 <u>TREATMENT OF ECCENTRIC OBSERVATIONS</u>). Two forepoints are involved with every horizontal angle observation; the value given must be the <u>clockwise</u> 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.

<u>Set Number</u>: 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.

<u>Number of Angles Observed in This Set</u>: 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.

<u>Date and Time</u>: 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, Designation and *30* record).

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, nothing should be added, 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 -
   Examples: JONES CLALLAM CO and JONES KING CO; SMITH ORLEANS PA and SMITH DE SOTO PA; ROCK KENAI-COOK INLET CD and ROCK ANCHORAGE CD.

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

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 <u>INTRODUCTION</u>). 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.

<u>Name or Designation of RM or AZ MK</u>: 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 Station Name), 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.

Name or Designation of Bench Mark: 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 Station Name 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. Order Codes of Permanently Marked Stations:

   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. Order Codes of Nonrecoverable Points:

   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, PROJECT DATA RECORDS), 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 higher 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 positive when the geoid is above the ellipsoid and that it is negative when the geoid is below the ellipsoid. The geoid height value given should be accompanied by an estimate of its absolute accuracy in the form of a standard error (Sigma).

Deflection of Vertical: 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 Meridional Component (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 Direction of Xi must be specified as "N" or "S" according to whether the astronomic latitude falls north or south of the corresponding geodetic latitude. The Prime-Vertical Component (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 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. 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.

<u>Survey Method Codes</u>

1 - Triangulation

2 - Trilateration

3 - Traverse

4 - Global Positioning System

<u>Order and Class of Survey Codes</u>

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, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.
CC 40-45	DATE OF OBSERVATION. YEAR, MONTH, DAY (YYMMDD). SEE CHAPTER 2, PAGES 2-18, DATE AND TIME.
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM). SEE CHAPTER 2, PAGE 2-7, TIME, AND PAGE 2-18, DATE AND TIME.
CC 50	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED. SEE CHAPTER 2, PAGE 2-7, TIME ZONE.
CC 51-54	SSN OF TARGET STATION. 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 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, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.
CC 59	VISIBILITY CODE. SEE CHAPTER 2, PAGE 2-11, VISIBILITY CODE.
CC 60-61	NUMBER OF REPLICATIONS. NUMBER OF POINTINGS OR MEASUREMENTS USED TO DETERMINE A HORIZONTAL DIRECTION. SEE CHAPTER 2, PAGE 2-16, NUMBER OF REPLICATIONS 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, REJECTION LIMIT.
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, HORIZONTAL DIRECTION DATA RECORDS.
CC 73-76	INTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE CHAPTER 2, PAGE 2-17, INTERNAL CONSISTENCY SIGMA.
CC 77-80	EXTERNAL CONSISTENCY. SIGMA IN SECONDS (SSss). ENTER ONLY IF RELIABLE ESTIMATES ARE AVAILABLE. SEE CHAPTER 2, PAGE 2-17, EXTERNAL CONSISTENCY SIGMA.

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

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^{TM}; M = Macrometer^{R}; 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.

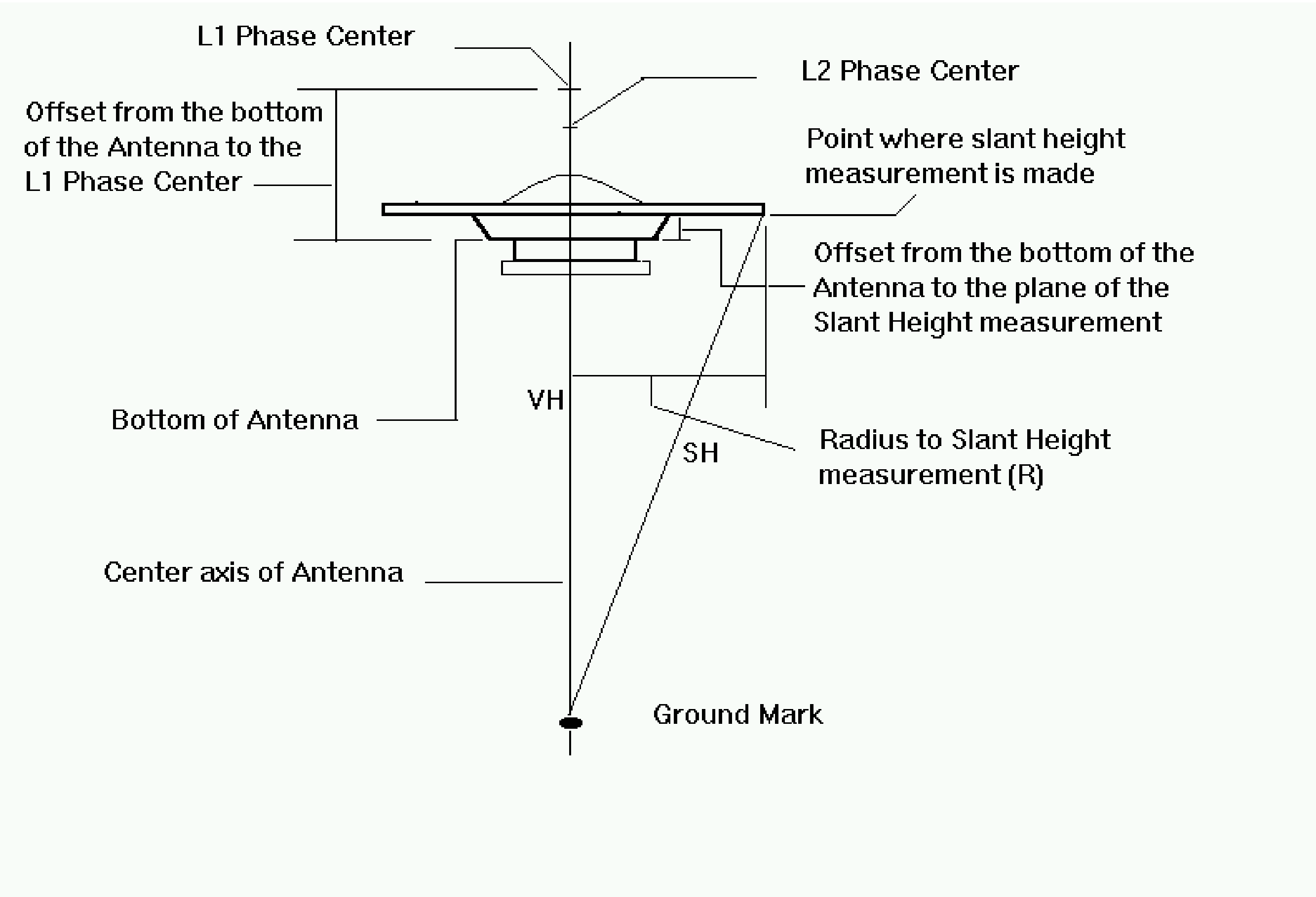
GPS OCCUPATION MEASUREMENT RECORD (*27*)

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.

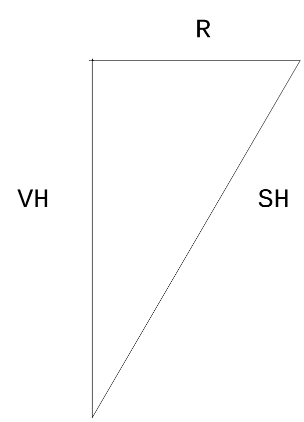
$$VH=\sqrt{SH^2-R^2}$$

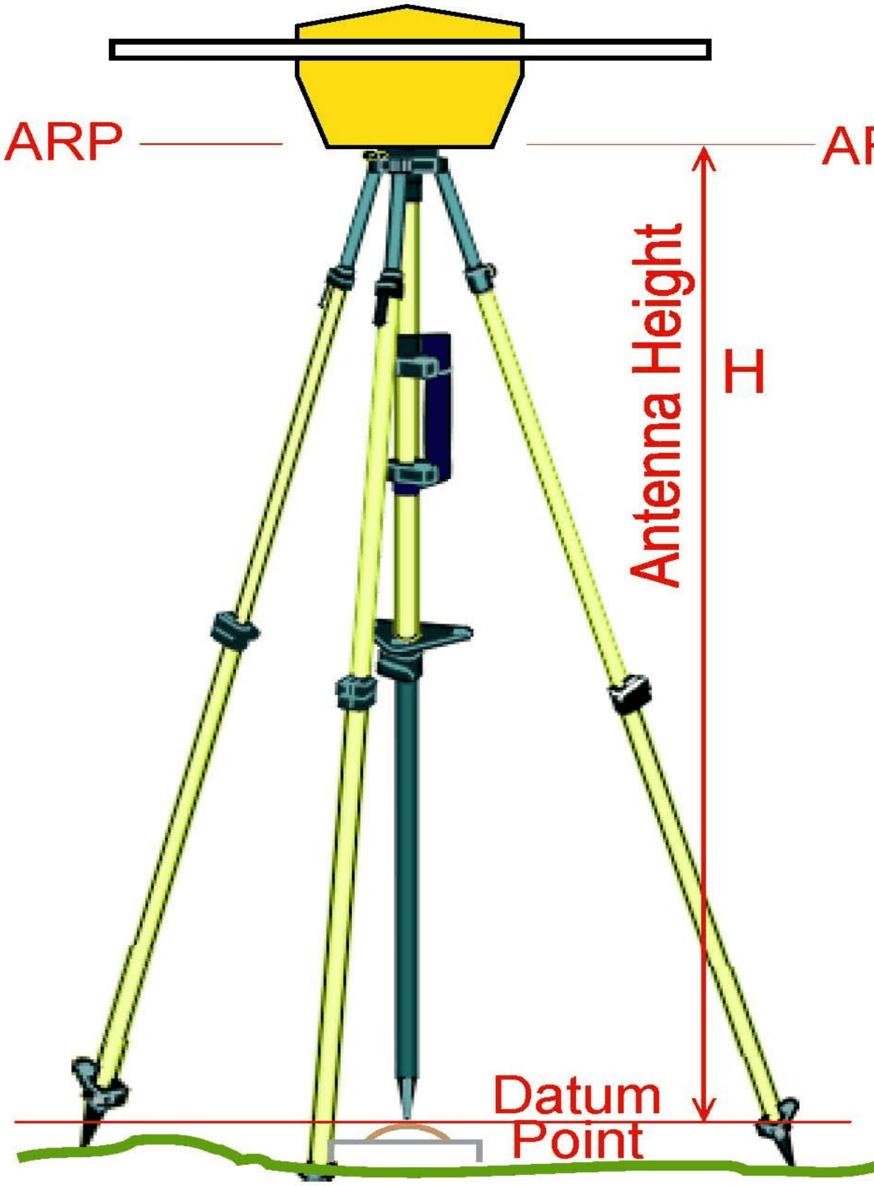
VH = Vertical Height as reduced from the slant height measurement.

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, HORIZONTAL DIRECTION DATA RECORDS.

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, DATE AND TIME.
CC 46-49	LOCAL TIME. HOURS, MINUTES (HHMM) SEE CHAPTER 2, PAGE 2-7, TIME; AND PAGE 2-20, DATE AND TIME.
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, JOB CODE AND SURVEY POINT NUMBERING; CHAPTER 2, 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 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, HEIGHT OF INSTRUMENT AND HEIGHT OF TARGET.
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, HORIZONTAL ANGLE DATA RECORDS.
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, HORIZONTAL ANGLE DATA RECORDS.
CC 72-75	SSN OF SECOND TARGET STATION (RIGHT FOREPOINT). SEE PAGES 1-1 THROUGH 1-3, JOB CODE AND SURVEY POINT NUMBERING; 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 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.

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, <u>LEVEL DATA RECORDS</u>, 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, <u>TIME</u> AND 2-24, <u>DATE AND TIME</u>.
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, DISTANCE DATA RECORDS.

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, WEATHER CODE.
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, TIME AND 2-25, DATE AND TIME.
CC 45	TIME ZONE. ENTER THE LETTER FROM 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	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, ACCURACY OF THE OBSERVATIONS.

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, <u>ACCURACY OF THE OBSERVATIONS</u>.

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, <u>ACCURACY OF THE OBSERVATIONS</u>.

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, TIME AND 2-27, DATE AND TIME.
CC 50	TIME ZONE. ENTER THE LETTER CODE FROM ANNEX H WHICH REPRESENTS THE TIME ZONE OCCUPIED. REFER TO PAGE 2-7, TIME ZONE.
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). DO NOT APPLY 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, Survey Equipment Data Records.

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, RESOLUTION OF THE INSTRUMENT AND UNITS.
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, Survey Equipment Data Records. 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, 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	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, STATION ORDER AND TYPE 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. Do not 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, JOB CODE AND SURVEY POINT NUMBERING AND 2-12 THROUGH 2-13, ASSIGNMENT OF STATION SERIAL NUMBERS.
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, NAME OR DESIGNATION OF RM OR AZ MK.
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	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, <u>JOB CODE AND POINT NUMBERING</u> and Chapter 2, pages 2-1 through 2-3, <u>HZTL OBS DATA SET RECORDS</u>.