Input Formats and Specifications of the National Geodetic Survey Data Base

Volume III. Gravity Control Data

Silver Spring, MD 20910
September 1994

Reprinted December 1997 with Updates to:

Annex A (See Volume I)
C
F
I
K
N

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Coast and Geodetic Survey

September 1994

POLICY OF THE NATIONAL OCEAN SERVICE REGARDING THE INCORPORATION OF GEODETIC DATA OF OTHER ORGANIZATIONS INTO THE NATIONAL GEODETIC SURVEY DATA BASE

The National Ocean Service (NOS), Coast and Geodetic Survey, National Geodetic Survey (NGS), has determined that the value to the National Spatial Reference System (NSRS) of geodetic observations obtained by other Federal, state, and local organizations compensates for the costs incurred by the Federal Government to provide quality assurance, archiving, and distribution functions for surveys contributing to the public good. Agencies submitting data must adhere to the following requirements. The final decision whether to accept data will be the responsibility of the Chief, NGS.

FORMAT

The survey data must be submitted in the automated formats specified in the Federal Geographic Data Committee (FGDC), Federal Geodetic Control Subcommittee (FGCS), publication Input Formats and Specifications of the National Geodetic Survey Data Base (September 1994), which describes the formats and procedures of submitting data for adjustment and assimilation into the NGS data base. Separate volumes of this publication refer to horizontal control data (volume I), vertical control data (volume II), and gravity control data (volume III). Guidelines for submitting three-dimensional Global Positioning System (GPS) relative positioning data are contained in Annex L of volume I.

ACCURACY

Standards of accuracy are given in Standards and Specifications for Geodetic Control Networks (1984) and Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques (May 1988).

The survey data must be properly formatted as set forth by FGCS and meet the minimum accuracy requirements of:

First-order horizontal accuracy standards for GPS or conventional horizontal surveys.

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

Third-order gravity accuracy standards for gravity surveys.

In addition, these data standards and accuracies must be verified, using currently available NGS software, by the provider prior to submitting the survey project to NGS.

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

MONUMENTATION

Monumentation must be uniquely identified and conform to minimum prescribed standards. Guidelines for control monuments are given in NOAA Manual NOS NGS 1 (1978), Coast and Geodetic Survey Special Publication 247 (1950), and in Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, appendix H (May 1988). Monument descriptions must be submitted in the automated format specified in Input Formats and Specifications of the National Geodetic Survey Data Base (September 1994).

FIELD RECORDS

Original field records (or acceptable copies) are requested with data submission. NGS will retain these records in the National Archives and Records Administration. This is necessary in the event that questions arise concerning the surveys upon which the adjusted data are based. Where digital records are required, e.g., GPS projects, such records will be submitted to NGS in a format specified by NGS at the time of submission. If field records are not submitted with the data, NGS reserves the right to inspect these records upon request. If field records are not submitted on request, NGS reserves the right to not accept and/or not publish the data, and if published, a disclaimer may be attached to the published data.

PROJECT REPORT

A project report, including sketches, is required for geodetic control projects. It should be submitted with the data and adhere to the form outlined in annexes K and L (GPS) of Input Formats and Specifications of the National Geodetic Survey Data Base (September 1994).

REVIEW

Reconnaissance reports describing proposed connections to the NSRS, along with the planned instrumentation and field procedures, must be submitted prior to beginning a project. This will enable NGS to comment on the proposed connections, using information available in the NGS data base concerning the accuracy and condition of these points, and to assure conformance with minimum accuracy standards and criteria. The project review could save the submitting agency the expense of placing data in computer-readable form that will fail accuracy or monumentation criteria. NGS work schedules and computer requirements can also be developed from this information. Upon receipt of the reconnaissance reports, NGS will respond within 10 working days.

RETURNED SUBMISSIONS

With verbal concurrence of the submitting organization, a limited number of errors in the submitted data will be corrected by NGS. Beyond a reasonable limit of about 1 percent, the entire project will be returned to the sender.

SUBMITTED PROJECTS

Projects must be submitted such that the unit of field work will compute independently of other projects. They must be connected to points already in the NGS data base. All data pertaining to a project (observations, descriptions, adjustments, reports, etc.) must be simultaneously received by NGS. Due to a limited capability to review, analyze, and edit survey data before they are loaded into the NGS data base, data contributed for inclusion into the data base should be processed and adjusted by the provider, using currently available NGS software, prior to submittal to NGS.

COST

There is no cost to submitters for NGS quality review, archiving, and distribution functions for survey data submitted according to the requirements discussed above. When NGS is requested to provide on-site instruction with respect to data formatting and/or data processing, the requesting organization will be charged for travel and per diem costs.

PUBLICATIONS

All the publications referenced in this statement are available from the National Geodetic Information Branch, N/CG174, NOAA, 1315 East-West Highway, Silver Spring, MD 20910-3282.

Telephone (301) 713-3242 Fax (301) 713-4172

PREFACE

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

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

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

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

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

Third-order gravity standards for gravity surveys.

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

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

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

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

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

NOAA, National Geodetic Survey, N/NGS12
1315 East-West Highway, Station 9202
Silver Spring, MD 20910-3282
Telephone: (301) 713-3242; Fax: (301) 713-4172
Monday through Friday, 7:00 a.m. - 4:30 p.m. Eastern Time.

CONTENTS - VOLUME III

Note: Volume I (Chapters 1-3, Annexes A-I,K,L,N) contains input formats and specifications for horizontal control data, Volume II (Chapters 5-6, for Annexes A,C,D,E,F,H,I,K see Volume I) contains input formats and specifications for vertical control data. Chapter 3, Geodetic Control Descriptive (GEOD DESC) Data of Volume I contains the input formats and specifications which are used for Gravity Descriptive (GRAV DESC) Data in this volume.

CONTENTS - VOLUME III PAGE

CONTENTS - VOLUME III PAGE

CHAPTER 9

GRAVITY CONTROL (GRAV) DATA

INTRODUCTION

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

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

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

MODE 2 - Adjusted Gravity Data (GRAV ADJU data)

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

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

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

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

JOB CODE AND SURVEY POINT NUMBERING

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

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

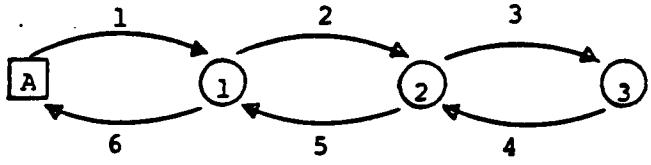
1. Ladder Sequence
2. Modified Ladder Sequence
3. Line Sequence

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

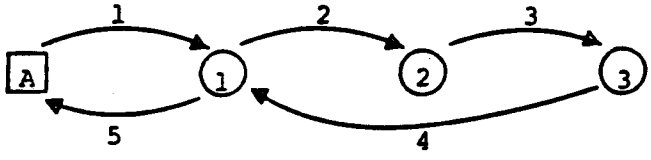
The modified ladder sequence loop also begins and ends at the same control point. However, not all the survey points are observed twice during the loop.

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

Figure 9-1 illustrates each of the loop sequences.

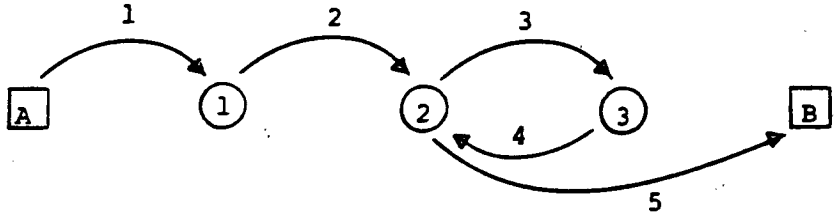


A. Ladder Sequence Loop (A-1-2-3-2-1-A for lines, A-B-C-B-A for Base Station Ties)



Reobserve at least 1 intermediate station.

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



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

KEY:

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

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

← = Observing sequence and direction.

Figure 9-1 Examples of Loop Sequences

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

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

MEDIA FOR SUBMITTING DATA

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

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

1. Name and address of the submitting agency.

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

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

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

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

1. Name and address of the submitting agency.

2. Reel number or identification symbol assigned by submitting agency.

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

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

5. Internal label information (non-labeled).

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

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

8. Record length (80) and block size.

9. Character representation code (ASCII).

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

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

A letter of transmittal in which the data are described and itemized should always be prepared for each data shipment. One copy should be enclosed with the data shipment, one sent by mail to the National Geodetic Survey, and another copy should be retained by the sender. See ANNEX K for the current mailing instructions. In every case, the submitting agency should retain a back-up of all data included in a shipment until the specific data have been sucessfully read by the National Geodetic Survey.

CODING, KEYING, AND DATA VERIFICATION

All data submitted to the National Geodetic Survey must be coded and keyed in strict conformity with the formats and specifications contained in this publication. In addition, the keying of all data must be verified. Detailed formats and specifications for the coding and keying of gravity control jobs are contained in Chapter 10 (GRAV OBS data), Chapter 7 (VERT DESC data), and in Chapter 11 (GRAV ADJU data). The formats were designed to allow the keying and verification of the data to be accomplished on standard equipment. The 80-character record (card image format) has been adopted for all applications.

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

0 - number "zero" -- O - letter "O"

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

2 - number "two" -- Z - Letter "Z"

SPECIAL CHARACTERS

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

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

NOTE: A restriction on characters is imposed for the designations of survey points (see ANNEX D).

SEQUENTIAL RECORD NUMBERING

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

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

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

Chapter 10

GRAVITY OBSERVATION (GRAV OBS) DATA

INTRODUCTION

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

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

GRAV OBS DATA SET RECORDS

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

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

Within these categories, the respective data have been grouped into "records". A record is a string of characters containing data codes in a specific format. Every record in a GRAV OBS data set consists of 80 characters or "columns". Within each record, the 80 columns are divided into fixed-length fields, each field being the space reserved for a specific data item. Accordingly, for every desired data item, there exists a field of appropriate length into which the data items are entered as strings of alphanumeric characters. The set of rules according to which specific data items are converted into strings of alphanumeric characters to be entered in the fields of a record is known as the "format" of that record.

The types of records which may appear in a GRAV OBS survey job are listed in Table 10-1. Each type of record has been given a name, and a block diagram

TABLE 10-1
GRAVITY OBSERVATION DATA SET RECORDS

FIRST RECORD
AA - Data Set Identification Record

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

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

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

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

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

LAST RECORD
AA - Data Set Termination Record

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

illustrating the respective format has been prepared to serve as a model for that record - see FORMAT DIAGRAMS. An example OBS data set also appears in figure 10-1. Except for the first and last records of the data set, the second character field of each record (columns 7-10) contains a two-digit numerical data code, preceded and followed by an asterisk, which specifies the type of that record (*10*, *11*, ..., - see Table 10-1). The first and last records of the data set (the Data Set Identification Record and the Data

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

STRUCTURE OF THE GRAV OBS DATA SET

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

The GRAV OBS data set records which are bracketed by these two delimiter records may pertain to one or more units of field work; i.e., field observation data for several gravity surveys may be submitted in one GRAV OBS data set under the same job code, provided that the total number of survey points in the job does not exceed 9,999 (see Chapter 9). Each loop must be terminated by a *40* record. A *10* record following a *50* series record (or a *40* series record for a marine gravity survey) signifies the beginning of a new gravity survey within this data set.

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

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

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

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

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

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

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

4. Loop Termination Record:

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

5. Station Information Record:

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

55 Comment Record (optional, any number allowed)

SURVEY IDENTIFICATION DATA RECORDS

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

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

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

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

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

Two Digit Accuracy Codes

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

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

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

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

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

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

DATE AND TIME

The date of the GRAV OBS data set creation must appear on the Data Set Identification Record, and the dates on which survey operations commenced and

terminated are to be entered on the *10* Survey Information Record. In addition, character fields are reserved for the date and/or time on several other records of the GRAV OBS data set. Throughout the GRAV OBS data set, date and time are to be coded as follows:

Date: The full date is coded as an eight-digit integer number consisting of four two-digit groups denoting (from left to right) the last whole century, number of full years since the turn of century, month of the year, and day of the month (CCYYMMDD). For the 20th century, the "century" columns may be omitted, and the data coded as a six-digit integer number denoting the year, month, and day (YYMMDD). If the day is not known (e.g., in connection with old data extracted from archives for which the date is not fully specified), leave the last two columns of the field blank; if the month is not known, leave the last four columns of the field blank. For example, February 8, 1970, would be coded as follows:

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

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

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

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

SURVEY EQUIPMENT DATA RECORDS

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

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

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

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

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

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

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

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

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

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

Instrument Serial Number: Assigned by the manufacturer, the serial number is the ultimate identifier of a specific instrument. Serial numbers are normally numeric; however, alphabetic characters are often used as prefixes, suffixes, etc. For this reason, a serial number must be treated as alphanumeric information to be entered in the respective character field left-justified and blank-filled on the right.

The instrument serial number will be used together with the respective survey equipment code (see above) to create appropriate entries in the NGS Gravity Instrument File, to maintain these entries up to date, and to access this file for the retrieval of the respective calibration data in the course of routine processing of GRAV OBS data sets. It is therefore of utmost importance that the respective serial number be faithfully reproduced and that identical serial number representation be used consistently whenever reference is made to that specific instrument in any GRAV OBS data set.

OBSERVATION DATA RECORDS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Reading Variability

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

LOOP TERMINATION RECORDS

40 Loop termination Record
45 Comment Record

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

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

STATION INFORMATION RECORDS

50 Station Information Record
55 Comment Record

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

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

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

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

Designation: A control point or bench mark is normally identified by a numeric or alphanumeric symbol which is stamped on the disk marker (or is otherwise inscribed on the bench mark monument) to which is appended the abbreviation or acronym (see Annex C) of the agency whose name is precast in the monument - if other than the National Geodetic Survey, National Ocean Service, or Coast and Geodetic Survey (see Origin). For marks not having a precast agency name, append the acronym or abbreviation of the agency which set the mark (see Setting-by-Agency). If the agency cannot be determined, do not append an agency acronym or abbreviation. Less frequently, a bench mark is assigned a concise, intelligible name (e.g., when a horizontal control point also becomes a bench mark); the appropriate acronym or abbreviation should be appended to these also. A maximum of 25 characters (including all imbedded blanks) is allowed.

In every case, the survey point designation entered on the *50* record must be identical to the (primary) designation used to identify the same gravity control point in the companion GRAV DESC data set of the gravity control job - refer to Chapter 7. Use the same general guidelines for the designations of any survey points which lack descriptive data (e.g., undescribed temporary survey points which may have to be carried in the GRAV OBS data set but which do not appear in the conpanion GRAV DESC data set, i.e. Drift Station).

FORMAT DIAGRAMS

For each record which appears in a GRAV OBS data set (see Table 10-1), a block diagram has been prepared to illustrate the respective format. These "format diagrams" have been designed to fulfill the following objectives:

1. Each record is 80 characters long (standard punched card image).

2. Each record has a fixed format, i.e., every data field has a specific length and specific position within the record.

3. Each format diagram is a graphic image of the respective record.

4. Within the limits of available space, information and instructions concerning the data item to be entered in each data field are provided on the format diagrams to render them self-explanatory.

5. When appropriate, sample entities are shown in the data entry line of each format diagram.

6. Each data field is characterized as to its type by a string of lower-case characters which appear immediately below the data entry line.

Date Field Types:

1. Alpha Field (aa...a) - intended for a data item which is coded as a string of alphabetic, numeric, and special characters, with or without imbedded blanks, to be entered into the respective data field left-justified and blank-filled on the right. See Chapter 9 for a list of special characters which are allowed.

2. Blank Field (bb...b) - to be blank-filled. Data fields which are designated as blank fields must be left blank, i.e., no date items may be entered in these fields.

3. Floating-Point Field (ff...fdd...d) - intended for a data item which is coded as a decimal number, i.e., as a string of numeric characters (prefixed with a minus sign if the number is negative) which may not contain any imbedded blanks. If the decimal point is present, the character string representing the integer digits, the decimal point, and the decimal fraction digits may be positioned anywhere within the respective field (generally left-justified), and the unused columns of the data field are blank-filled.

When the decimal point is not coded, the "f" portion of the floating-point field is to contain the integer part of the decimal number, and the "d" portion the corresponding decimal fraction part, the decimal point being implied between the rightmost "f" column and the leftmost "d" column of the field.

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

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

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

Required Data: In general, only those records which are applicable to the data at hand should be included in a GRAV OBS data set. The character fields intended for data items which are essential have been shaded on the format diagrams; if applicable to the data being coded, these character fields must be in accordance with the instructions given on the respective format diagrams or in the text of this chapter. Records which are optional or those which may be omitted under certain circumstances are clearly designated in the headings, footnotes, or bodies of the corresponding format diagrams.

```
000000000111111111122222222223333333333444444444455555555556666666666777777777 8
123456789012345678901234567890123456789012345678901234567890123456789012345678 90

000010*AZ*GRAVOBS NGS   NATIONAL GEODETIC SURVEY                              19840906
000020*10*P02645       1984031919840320      12AZ    LMJNGS
000030*11*ARIZONA LAND SUBSIDENCE PROJECT
000040*15*GPS & LEVELING ALSO RUN ALONG SAME LINES
000050*20*014G081              LACOSTE    G-METER     NGS
000060*21*G081             LACOSTE             AUSTIN TEXAS            1
000070*25*ONLY SUFFICIENT TABLE I VALUES FOR THIS SURVEY SUBMITTED
000080*22*250000025723502600000267537027000002778400280000028814302900000298447 0
000090*22*300000030875203100000319059032000003293670330000033967703400000349989 0
000100*23*G081      78    LACOSTE
000110*24*1.000259
000120*20*015D043             LACOSTE    D-METER     NGS
000130*23*D043      81    LACOSTE
000140*24*1.2424
000150*30*   802     0G081          18403191515   292531002LMJ10423802
000160*30*   802     0D043           8403191530    10005502LMJ10423802
000170*30*   001    20G081          18403191559   293614002LMJ16423602
000180*30*   001    20D043           8403191610    10904402LMJ16423602
000190*30*   002    20G081          18403191623   294185002LMJ16523402
000200*30*   002    20D043           8403191625    11380302LMJ16523402
000210*30*   003    70G081          18403191640   294705002LMJ17623402
000220*30*   003    70D043           8403191650    11798002LMJ17623402 R
000230*35*THIS WAS A BAD READING.  OBSERVATION BEING REPEATED
000240*30*   003    70D043           8403191650    11799002LMJ17623402
000250*30*   802     0G081          18403200057   292523002LMJ25525202
000260*30*   802    0D043            8403200105    10003602LMJ25525202
000270*40*
000280*45*FIRST HALF OF LADDER SEQUENCE FINISHED
000290*30*   802     0G081          18403201549   292531002LMJ19524802
000300*30*   802     0D043           8403201601    10007902LMJ19524802
000310*30*   002    20G081          18403202124   294165002LMJ30725502
000320*30*   002    20D043           8403202132    11366502LMJ30725502
000330*30*   003    65G081          18403202155   294685002LMJ33025802
000340*30*   003    65D043           8403202203    11796002LMJ33025802
000350*30*   001    20G081          18403202211   293583502LMJ31525802
000360*30*   001    20D043           8403202220    10886102LMJ31525802
000370*30*   802     0G081          18403202247   292509002LMJ31126002
000380*30*   802     0D043           8403202253    09991302LMJ31126002
000390*40*
000400*50* 802AN 51                    CZ1510 3246360C 11136000C  463743I
000410*55*AN 51 IS THE BASE STATION FOR THIS SURVEY
000420*50* 001X 278                     CZ1034 3247480C 11137360C  457681I
000430*50* 002AL 49 USE                 CZ1031 3248240C 11138060C  453266I
000440*50* 003Q 363                     CZ1032 3249180C 11138060C  456558I
000450*AZ*

000000000111111111122222222223333333333444444444455555555556666666666777777777 8
123456789012345678901234567890123456789012345678901234567890123456789012345678 90
```

FIGURE 10-1 - Example of OBS Date Set

TABLE I

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

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

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

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

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

Columns 1–6	Columns 7–10	Columns 11–14	Columns 15–18	Columns 19–24	Columns 25–66	Columns 67–72	Columns 73–80
000000 123456	0001 7890	1111 1234	1111 5678	122222 901234	222223333333333444444444455555555556666666 567890123456789012345678901234567890123456	666777 789012	77777778 34567890
Sequence Number - must be 000010 on this record. Increment by 10 on successive records to allow for insertions.	Data Set Identification: Job Code - preceded and followed by asterisk.	Data Set Identification: Data Class - GRAV for Gravity control data.	Data Set Identification: Data Type - OBS for field observation data.	Name of Submitting Agency or Firm: Abbreviation - must be unique. Enter the symbol listed in ANNEX C. See footnote for other agencies or firms	Name of Submitting Agency or Firm: Full Name		Date Data Set Created (e.g. date this record keyed) Century, year, month, day (CCYYMMDD). If day is unknown, leave last columns blank. If month is unknown, leave last four columns blank.
000010	*CA*	GRAV	OBS	USGS	US GEOLOGICAL SURVEY		19820512
iiiiii	saas	aaaa	aaaa	aaaaaa	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa	bbbbbb	iiiiiiii
000000 123456	0001 7890	1111 1234	1111 5678	122222 901234	222223333333333444444444455555555556666666 567890123456789012345678901234567890123456	666777 789012	77777778 34567890

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

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

0000000001111111112222222223333333334444444445555555556666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890			
			bbbb
	Order and Class of Survey Order: 1st (Class: - / I / II; Code: 10 / 11 / 12); 2nd (**; 20); 3rd (**; 30); Lower (**; 40) * Class unspecified ** No class subdivision Agency which made the observations. For agencies or firms listed in ANNEX C, enter the respective six-character abbreciation. For others enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.	RWJUSGS	aaaaaaaaaaaaaaaaaaaa
	Initials of Chief of Party - i.e., person responsible for the survey, leave blank if unknown.		aaa
	State or Country Code - See ANNEX A. Enter the code(s) for the state (or country) in which the line begins (and into which it extends).	11CA	aaaaaaaaaaaaaaaaaaaa
	Order and Class of Survey - See table above.		bbbbbbbbbbbbbbbbbbbb
	Date Field Observations Terminated Century, year, month, day (CCYYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.	19820413	iiiiiiiiiiiiiiiiiiii
	Date Field Operations Commenced Century, year, month, day. (CCYYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.	19820124	iiiiiiiiiiiiiiiiiiii
	Resurvey Code - See footnote	R	a
	Agency - specific pointer to its own archives - usually given as an "accession number" (or other cataloguing symbol) which identifies the block of data, possibly supplemented by a further "line" or "part" designation. Line/Part (Optional) Accession Number	1 P02618	aaaaaaaaaa
	Data Code - preceded and followed by asterisk. ("10" - Survey Information Record)	*10*	siiisaaaaa
	Sequence Number Increment by 10 on successive records to allow for insertions.	nnnnnn	iiiiii

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

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

00000000011111111122222222223333333334444444445555555556666666667777777778 12345678901234567890123456789012345678901234567890123456789012345678901234567890	
	Survey Title - use *12*, *13*, *14* Survey Title Continuation Record(s) as required if the title exceeds 70 characters or if subtitles are necessary (e.g. the title of an area network followed by title of the line). The title of a survey line should be descriptive of the route followed, i.e., it should indicate the starting and ending locations and prominent "via" points, if any (Example: ALBANY GA VIA MORVEN TO CALLAHAN FL). Do not divide words (or other character groups) between the *11*, *12*, *13*, *14* Survey Title and Survey Title Continuation Records. Omit punctuation marks (periods, commas, etc.) and parentheses whenever possible. Use ANNEX A state and country codes whenever reference to a state or country is necessary. Abbreviate and/or edit a Survey title in the interest of fitting the entire title on the *11* Survey Title Record, if possible.
00000000011111111122222222223333333334444444445555555556666666667777777778 12345678901234567890123456789012345678901234567890123456789012345678901234567890	
nnnnnn*11*REOBSERVATIONS OF GRAVITY STATIONS FOR EARTHQUAKE STUDIES, CA	Data Code *11*, *12*, *13*, *14* Survey Title Records
nnnnnn*12*WISTER SOUTH TO COLEXICO, DIXIELAND EAST VIA EL CENTRO TO HOLTVILLE	Sequence Number Increment by 10 on successive records to allow for insertions.
iiiiiisiisaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa	
00000000011111111122222222223333333334444444445555555556666666667777777778 12345678901234567890123456789012345678901234567890123456789012345678901234567890	

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

000000 123456	0001 7890	1111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Sequence Number Increment by 10 on successive records to allow for insertions.	Data Code ("15" - Comment Record)	Comment
nnnnnn	*15*	LEVELS OBSERVED OVER THIS SURVEY
iiiiii	siis	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
000000 123456	0001 7890	1111111112222222222333333333344444444445555555555666666666677777777778 1234567890123456789012345678901234567890123456789012345678901234567890

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

0000000001111111112222222223333333334444444445555555556666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890						
	Agency which owns or has the custody of the instrument. For agencies or firms listed in ANNEX C, enter the respective six-character abbreviation. For others, enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.		DMA			
	Model of Type - examples: G-meter D-meter		G-METER			
	Manufacturer - examples: La Coste Worden		LACOSTE			
	Instrument Serial Number - alphanumeric, left-justified.					
	NGS Survey Equipment Code - see ANNEX F.		14			
	Data code ("20" - Instrument Information Record)	*20*				
	Sequence Number Increment by 10 on successive records to allow for insertions.	nnnnn				
0000000001111111112222222223333333334444444445555555556666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890						

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

00000000011111111122222222223333333334444444445555555556666666667777777778 12345678901234567890123456789012345678901234567890123456789012345678	Calibration Serial Number- Job specific identifier for corresponding observations.	80
	Location where calibration was performed.	AUSTIN TEXAS
	Agency which determined or performed the calibration. For agencies or firms listed in ANNEX C, enter the respective six-character abbreviation. For others, enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.	LACOSTE
	Date Determined - year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.	861016
	Instrument Serial Number - alphnumeric, left-justified.	G130
	Data Code ("21" - Instrument Calibration Header Record)	21
	Sequence Number Increment by 10 on successive records to allow for insertions.	10

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

00000000011111111112222222223333333334444444445555555556666666667777777778 12345678901234567890123456789012345678901234567890123456789012345678901234567890	
nnnnn	Sequence Number Increment by 10 on successive records to allow for insertions.
22	Data Code (*22* - Instrument Calibration Information Record)
iiiiiisiiis	Counter Dial Units - The observed values from the gravity meter during the calibration. The first entry on the first *22* record must be the lowest counter dial unit encountered during calibration (see text chapter 10). Decimal point implied after column 14.
0000000000000000000000	Mgal Value - Corresponding Mgal Value for the preceding Counter Dial Unit. Decimal point implied after column 21.
fffddddfffddddfffddddf	Counter Dial Units Decimal point implied after column 28.
0100000	
fffddddfffddddfffddddf	Mgal Value Decimal point implied after column 35.
0109980	
fffddddfffddddfffddddf	Counter Dial Units Decimal point implied after column 42.
0200000	
fffddddfffddddfffddddf	Mgal Value Decimal point implied after column 49.
0209950	
fffddddfffddddfffddddf	Counter Dial Units Decimal point implied after column 56.
0300000	
fffddddfffddddfffddddf	Mgal Value Decimal point implied after column 63.
0314310	
fffddddfffddddfffddddf	Counter Dial Units Decimal point implied after column 70.
0400000	
fffddddfffddddfffddddf	Mgal Value Decimal point implied after column 77.
0419860	

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

00000000011111111122222222223333333334444444445555555556666666667777777778 12345678901234567890123456789012345678901234567890123456789012345678901234567890			
nnnnnn	Sequence Number Increment by 10 on successive records to allow for insertions.		
23	Data Code ("23" - Instrument Scale Factor Header Record)		
G130	Instrument Serial Number - alphanumeric, left-justified.		
661018	Date Determined - year, month, day (YYMMDD). If day is unknown, leave last two columns blank. If month is unknown, leave last four columns blank.		
LACOSTE	Agency which determined or performed the scale factor determination. For agencies or firms listed in ANNEX C, enter the respective six-character abbreviation. For others, enter the full or abbreviated name (up to 20 characters) - see ANNEX C for examples.		
0000000	Lowest value in counter dial units for which this scale factor is appropriate.		
7000000	Highest value in counter dial units for which this scale factor is appropriate.		

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

00000000011111111122222222233333333334444444445555555556666666667777777778 12345678901234567890123456789012345678901234567890123456789012345678901234567890			
nnnnnn	Sequence Number Increment by 10 on successive records to allow for insertions.		
000000	Data Code (*24* - Instrument Scale Factor Record)	*24*	
1.000082	Scale Factor - The scale factor is used in conjunction with, or in lieu of, values supplied in the *21* and *22* records. The use of scale factors and interval values is extremely instrument dependent. The end result however should be the conversion of observations to mgal values.	f	
0.000003	Standard Deviation of Scale Factor - complete this field if known.	f	

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

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

30 Land Observation Record (Running Record) Submit this record for every observation. A separate *30* record is required for each instrument used at a particular location. Any instrument may be indicated on the *30* record providing *20*, *22* and *24* records for that instrument have been recorded prior to the *30* record.

	Reserved for Agency Use - See Footnote		
Atmospheric Pressure (millibar)		2	7713
Temperature of Air (Tenths - Degree Celsius)		2	1003
Initials of Observer			
Wind and Sun Code - see footnote			
Reading of Instrument - Decimal implied after column 53. For relative instruments, reading is dial reading. For Absolute, gravity value obtained.			
Time of Reading			
Date of Reading - year, month, day(YYMMDD)		D	932
Instrument Calibration Serial Number - Must correspond with calibration information on *21* recd.			
Instrument Serial Number - number must agree with A *20* record submitted with survey data with the job.			
Height of Instrument (HI) - (nn) - Distance from bottom of meter to control point. (-) indicates in column 17 for stations above instrument. Right justified.		7	0
Survey Point Serial Number (SPSN) - see Chapter 8 Must be same as SPSN used in GRAV DESC data set and on *50* record.		D	732
Data Code (*30* = Land Observation Record (Running Record))			304
Sequence Number Increment by 10 on successive records to allow for insertions.			

Wind Code: 0 - less than 10 km/hour, 1 - 10-25 km/hour, 2 - more than 25 km/hour wind speed.
Sun Code: 0 - less than 25%, 1 - 25-75%, 2 - more than 75% of solid under sunny conditions.
Reading Quality Indicator: 0 - steady (normal), 1 - slight variation, 2 - moderate variation, 3 - excessive variation, 9 - tare suspected

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

0000000001111111112222222223333333334444444445555555556666666667777777778 / 1234567890123456789012345678901234567890123456789012345678901234567890		
	Acceptance Criteria - Reject obs if "R". Accept if blank.	
	Reading of Instrument - Decimal implied between column 75 and 76.	2730440
	Time of Reading - hours, minutes, seconds (HHMMSS)	080110
	Date of Reading - year, month, day (YYMMDD)	860829
	Height of Instrument (HI) - (mm) - See text.	5100
	Depth Accuracy Code	K
	Depth - (MMMMMm) - Depth of bottom surface below sea level. Decimal implied between columns 48 and 49.	24334
	Longitude Accuracy Code	J
	Longitude - (±DDDMMSSs) - Same as *50* record. Decimal implied between column 39 and 40.	13015455
	Latitude Accuracy Code	J
	Latitude - (±DDMMSSs) - Same as *50* record. Decimal implied between column 29 and 30.	10-2045530
	Instrument Calibration Serial Number - See footnote	
	Instrument Serial Number - Same format as *30* record.	
	Data Code (*32* - Marine Observation Record)	*32*S51
	Sequence Number Increment by 10 on successive records to allow for insertions.	nnnnnn

Accuracy Codes (Depth, Latitude, Longitude)

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

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

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

000000 123456	0001 7890	11111111122222222223333333333444444444455555555556666666666777777777 8 12345678901234567890123456789012345678901234567890123456789012345678 90
Sequence Number Increment by 10 on successive records to allow for insertions.	Data Code (*35* - Comment Record)	Comment
nnnnnn	*35*	NECESSARY TO CHANGE BATTERY AT 1435 HRS GCT
iiiiii	siis	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
000000 123456	0001 7890	11111111122222222223333333333444444444455555555556666666666777777777 8 12345678901234567890123456789012345678901234567890123456789012345678 90

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

000000 123456	0001 7890	11111111122222222223333333333444444444455555555556666666666777777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Sequence Number Increment by 10 on successive records to allow for insertions.	**Data Code** ("40" - Loop Termination Record)	
nnnnnn	*40*	
iiiiii	siis	bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
000000 123456	0001 7890	11111111122222222223333333333444444444455555555556666666666777777777778 1234567890123456789012345678901234567890123456789012345678901234567890

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

000000 123456	0001 7890	1111111111222222222233333333334444444444555555555566666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Sequence Number Increment by 10 on successive records to allow for insertions.	Data Code ("45" - Comment Record)	Comment
nnnnnn	*45*	CHECK THIS LOOP
iiiiii	siis	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
000000 123456	0001 7890	1111111111222222222233333333334444444444555555555566666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890

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

0000000001111111112222222223333333334444444445555555556666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890			
	Elevation Code - see box		bbbbbbb
	Elevation - (MM) Most accurate existing elevation known at time of survey, expressed in millimeters. (-) in column 65 indicates below sea level datum. Right justified.		iiiiiiii
	Longitude Code - see box		aaaaaaaaa
	Longitude - (±DDDMMSSs) - Longitude expressed as ± degrees, minutes, seconds and tenths of seconds. (-) indicates East. Decimal implied after column 62.		fffffffff
	Latitude Code - see box		aaaaaaaaa
	Latitude - (±DDMMSSs) - Latitude expressed as ± degrees, minutes, seconds and tenths of seconds. (-) indicates South. Decimal implied after column 52.		fffffffff
	Archival Cross Reference Number (ACRN) - NGS specific, complete if known, otherwise leave blank.		aaaaaaaaa
	Designation - must not exceed 25 characters. This is the primary designation which will be associated with the gravity control point for publication purposes. In every case, the designation must be edited in conformity with Guidelines for Survey Point Names and Designations (ANNEX D). The designation entered in this field must be identical (character for character) with the designation given for the same point in the corresponding GRAV DESC data set.		aaaaaaaaa
	Survey Point Serial Number (SPSN) - see chapter 9. Must be same as SPSN used in GRAV DESC data set.		iiiiiiiii
	Data Code ("50" - Station Designation Record)		nnnnn
	Sequence Number Increment by 10 on successive records to allow for insertions.		iiiiiiiii

Accuracy Codes for Elevation

Accuracy Range (Meters)		
Low	Code	High
-	I	.01
.01	J	1
1	K	10
10	L	25
25	M	50
50	N	-

Accuracy Codes for Latitude, Longitude

Accuracy Range (Arc Min., Sec.)		
Low	Code	High
-	A	1"
1"	B	10"
10"	C	1'
1'	D	5'
5'	E	10'
10'	F	20'
20'	G	-

0000000001111111112222222223333333334444444445555555556666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890
*50*1513J 1083 RESET 1973 DR0732 3239452A 1153000W 34700K

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

000000 123456	0001 7890	1111111111222222222233333333334444444444555555555566666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890
Secuence Number Increment by 10 on successive records to allow for insertions.	Data Code (*55* - Comment Record)	Comment
nnnnnn	*55*	NO ACRNS AVAILABLE FOR THIS SURVEY
iiiiii	siis	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
000000 123456	0001 7890	1111111111222222222233333333334444444444555555555566666666667777777778 1234567890123456789012345678901234567890123456789012345678901234567890

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

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

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

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

Job Code - preceded and followed by asterisk.

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

Chapter 11

ADJUSTED GRAVITY CONTROL (GRAV ADJU) DATA

INTRODUCTION

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

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

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

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

A block diagram illustrating the respective format has been prepared to serve as a model for the Adjusted Gravity Station Data Record. A record is a string of characters containing data coded into a specific format. Every record in a GRAV ADJU data set consists of 80 characters called columns (standard punch card format). Within each record the 80 columns are divided into fixed length "character fields", each field being the space reserved for a specific data item. Accordingly, for every desired data item, there exists a field of appropriate length in which the data items are converted into strings of alphanumeric characters. The set of rules by which specific data items are converted into strings of alphanumeric characters to be entered in the fields of a record is known as the "format" of that record.

ADJUSTED GRAVITY STATION DATA RECORD

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

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

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

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

C = Material classified CONFIDENTIAL
S = Material classified SECRET

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

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

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

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

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

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

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

ELEVATION UNITS

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

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

ELEVATION

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

SUPPLEMENTAL ELEVATION

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

ADJUSTED GRAVITY

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

FREE-AIR ANOMALY

A gravity anomaly is the difference between an adjusted gravity value which has been reduced to an equipotential surface known as the geoid and the corresponding normal gravity value on an ellipsoid. The ellipsoid is chosen so as to be a best fit to the geoid. A free-air anomaly is the difference between an adjusted gravity value which has been reduced to sea level (in an approximation of the geoid surface) and the corresponding normal gravity value on the reference ellipsoid. The correction for the sea level height of the gravity station (+0.3086 milligals/meter) is called the free-air correction. Because the actual

vertical gravity gradient at the gravity station is usually not known, the normal ellipsoidal gravity gradient is used for the free-air correction.

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

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

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

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

where ϕ is the geodetic latitude of the gravity station.

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

BOUGUER ANOMALY

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

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

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

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

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

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

where A_c = complete Bouguer Anomaly
T = Terrain Correction

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

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

where A_i = Isostatic Anomaly
A_{it} = Terrain corrected Isostatic Anomaly
I = Isostatic Correction

ISOSTATIC ANOMALY OR TERRAIN CORRECTION CODE:
The purpose of this field is to indicate which type of anomaly is in the Bouguer Anomaly field. The following codes should be used:

0 = Bouguer Anomaly.
1 = Terrain corrected Bouguer Anomaly.
2 = Isostatic anomaly.
3 = Terrain corrected Isostatic Anomaly.

SOURCE CODE
The source code is DoD specific and is assigned by DoD. Other submitting agencies should leave this field blank.

BASE REFERENCE STATION CODE
The base reference station code is used to identify the base station location used to determine the adjusted value of the gravity. This field is DoD specific and should be left blank by agencies outside of DoD. Agencies familiar with DoD policy may choose to use this field. Its use, however, is explicitly optional.

BASE REFERENCE SITE
The base reference site identifies the occupied point at the base station location. This field is DoD specific and should be employed only by DoD or agencies familiar with DoD policy.

GRAVITY STATION NUMBER
A gravity station number is assigned to each station within one source code. The gravity station number basically serves the same purpose as the SPSN for a GRAV OBS data set. Its use is agency specific and optional for the purpose of transmitting data to NGS.

FILE MAINTENANCE
This code is inactive and should be left blank.

ESTIMATION STANDARD DEVIATION FREE-AIR ANOMALY AND BOUGUER ANOMALY
This value is an estimation of the standard deviation of the Bouguer Anomaly. Standard Deviation (Error) connotes that there is a 68% probability that the free-air or Bouguer anomalies will fall between the indicated + or - values: e.g., if the free-air anomaly is 10 milligal with a ±2 milligal error or standard deviation, then there is 68% probability that the value lies between 8 and 12 mgals.

FORMAT DIAGRAM

For the Adjusted Gravity Station Data record (see Table 11-2), a block diagram has been prepared to illustrate the format. This 'format diagram' has been designed to fulfill the following objectives:

1. Each record is 80 characters long (standard punched card image).

2. Each record has fixed format, i.e., every data field has a specific length and specific position within the record.

3. Each format diagram is a graphic image of the respective record.

4. Within the limits of available space, information and instructions concerning the data item to be entered in each data field are provided on the format diagrams to render them self-explanatory.

5. When appropriate, sample entities are shown in the data entry line of each format diagram.

6. Each data field is characterized as to its type by a string of lower-case characters which appear immediately below the data entry line.

DATA FIELD TYPES

1. Alpha Field (aa...a) - intended for a data item which is coded as a string of alphabetic, numeric, and special characters, with or without imbedded blanks, to be entered into the respective data field left-justified and blank-filled on the right. See Chapter 9 for a list of special characters which are allowed.

2. Blank Field (bb...b) - to be blank-filled. Data fields which are designated as blank fields must be left blank, i.e., no data items may be entered in these fields.

3. Floating-Point Field (ff...fdd...d) - intended for a data item that is coded as a decimal number, i.e., as a string of numeric characters (prefixed with a minus sign if the number is negative) which may not contain any imbedded blanks. If the decimal point is present, the character string representing the integer digits, the decimal point, and the decimal fraction digits may be positioned anywhere within the respective field (generally left-justified), and the unused columns of the data field are blank-filled.

When the decimal point is not coded, the "f" portion of the floating-point field is to contain the integer part of the decimal number, and the "d" portion the corresponding decimal fraction part, the decimal point being implied between the rightmost "f" column and the leftmost "d" column of the field.

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

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

Required Data: In general, only those records which are applicable to the data at hand should be included in a GRAV ADJU data set. The character fields intended for data items which are essential have been shaded on the format diagram: if applicable to the data being coded, these character fields must be in accordance with the instructions given on the respective format diagrams or in the text of this chapter.

ADJUSTED GRAVITY STATION DATA RECORD. Submit this record for each adjusted gravity station, for which connecting observations are not available, for inclusion into the NGS gravity working file.

Columns	Description		
78-80	Standard Deviation Bouguer Anomaly - Estimate of the standard deviation of the bouguer anomaly in milligals		02
75-77	Standard Deviation Free-Air Anomaly - Estimate of the standard deviation of the free-air anomaly in milligals		02
74	File Maintenance DoD Specific (Optional)		
67-73	Gravity Station Number - (Optional) The Sequence Number of Each Station within a Survey		0932
66	Base Reference Site DoD Specific (Optional)		
62-65	Base Reference Station DoD Specific (Optional)		
56-61	Source Code - DoD Specific (Optional) A Source Code Assigned by the Submitting Agency		
55	Isostatic Anomaly or Terrain Correction (See Chapter II)	0	
49-54	Bouguer Anomaly in milligals Decimal Point is implied after Column 53	258	
43-48	Free-Air Anomaly in milligals Decimal Point is implied after Column 47	221	
33-40	Adjusted Gravity Adjusted Gravity Value - 976000.00 milligals Decimal Point is implied after Column 40	561320	
29-32	Supplemental Elevation Depth of Instrument, Lake or Ice. Positive Downward from Surface		
23-28	Elevation Decimal Point is implied after Column 28 This field will contain Depth of Ocean (Positive Downward) if Column 21 contains 3, 4 or 5	5505	
22	Elevation Units - 0=meters, 1=feet, 2=fathoms	1	0
21	Type of Elevation (See Chapter II)	0	
12-20	Longitude - Sign of Longitude in Column 12 (- for West) Decimal Point is implied: after Column 15 for Decimal Degrees after Column 17 for Degrees and Minutes after Column 19 for Degrees, Minutes and Seconds	-1620231	
1-10	Latitude - Sign of Latitude in Column 4 (- for South) Decimal Point is implied: after Column 6 for Decimal Degrees after Column 8 for Degrees and Minutes after Column 10 for Degrees, Minutes and Seconds	555959	
11	Geographic Units (See Chapter II)	1	
10	Security Control (See Chapter II)		
9	Security Classification (See Chapter II)		

ANNEX O

GRAVITY CONTROL FORMULAS
DEPARTMENT OF DEFENSE GRAVITY LIBRARY

Formulas Used in Computing Free-Air and Bouguer Anomalies

1. Symbology

Symbol	Definition	Units
g	Free-Air Anomaly	milligals
g	Bouguer Anomaly	milligals
ϕ	Latitude of Observation	degrees, minutes
γ	Theoretical Gravity	milligals
g	Observed Gravity	milligals
h	Elevation (Col 23-29) of surface of land, ice or water; depth of ocean, (positive downward) elevation types 3, 4, and 5. + = above SL; - = below SL.	meters
d	Supplemental Elevation (Col 31-35) = Depth of Ocean, lake, ice or instrument (positive downward)	meters

2. Theoretical Gravity Computation

Using the International Gravity Formula 1967

$$\gamma = C_1 (1 + C_2 \sin^2 \phi + C_3 \sin^4 \phi)$$

where: $C_1 = 978031.85$ mgals

$C_2 = 0.005278895$

$C_3 = 0.000\ 023462$

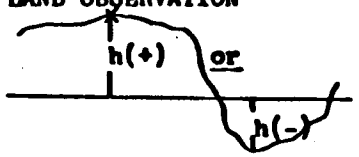
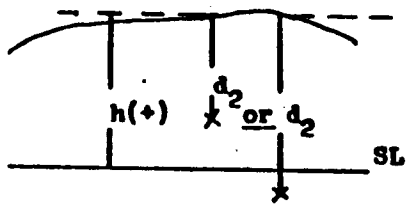
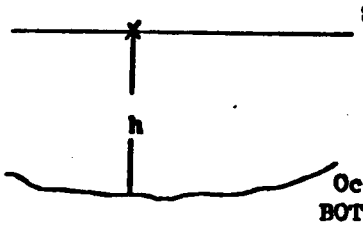
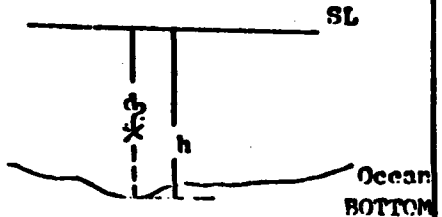
3. Anomaly Computations

b = Bouguer Correction Factor
= $2\pi K\rho = 0.04191\rho$

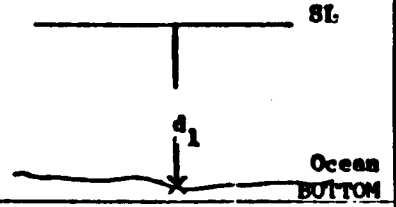
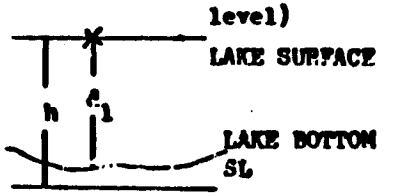
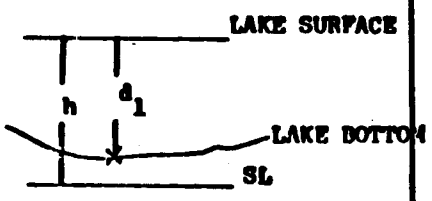
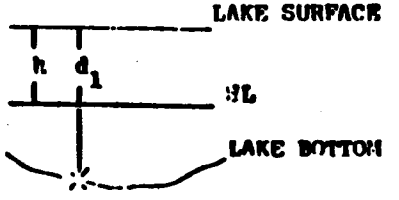
ρ = Density Used in Computations

Substance	ρ	$b = 2\pi K\rho$
Fresh Water	1.0	0.04191
Salt Water	1.027	0.04304
Ice	0.917	0.03843
Land	2.67	0.1119
Land-Fresh Water	1.67	0.06999
Land-Salt Water	1.643	0.06886
Land and Ice	1.753	0.07347

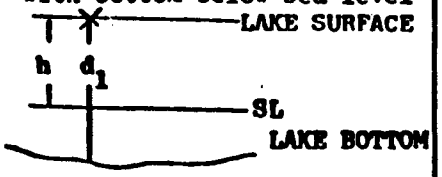
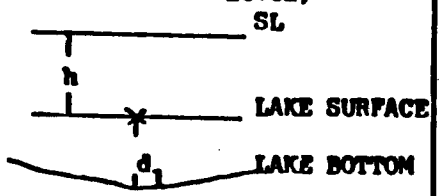
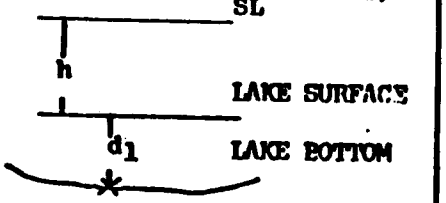
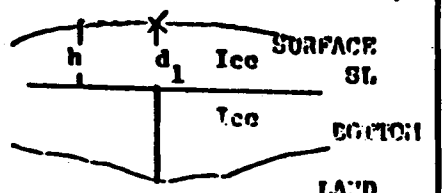
ANOMALY COMPUTATION CHART (p. 1)

Elev. Type Col. 21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
1	LAND OBSERVATION 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.1119h$
2	SUBSURFACE 	$\Delta g_f = g + 0.2238d_2 + 0.3086(h-d_2) - \gamma$ NOTE: d_2 = depth of instrument	$\Delta g_B = \Delta g_f - 0.1119h$
3	OCEAN SURFACE 	$\Delta g_f = g - \gamma$	$\Delta g_B = \Delta g_f + 0.06886h$ NOTE: h = depth of ocean positive downward from surface
h	OCEAN SUBMERGED 	$\Delta g_f = g - 0.2225d_2 - \gamma$ NOTE: d_2 = depth of instrument positive downward	$\Delta g_B = \Delta g_f + 0.06886h$ NOTE: h = depth of ocean positive downward

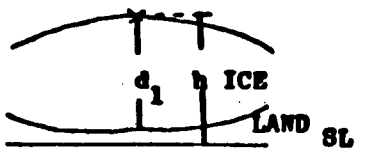
ANOMALY COMPUTATION CHART (p. 2)

Elev. Type Col.21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
5	OCEAN BOTTOM 	$\Delta g_f = g - 0.2225d_1 - \gamma$ NOTE: d_1 = depth of ocean positive downward	$\Delta g_B = \Delta g_f + 0.06886d_1$
6	LAKE SURFACE (above sea level) 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.04191d_1 - 0.1119(h-d_1)$ NOTE: d_1 = depth of lake positive downward
7	LAKE BOTTOM (above sea level) 	$\Delta g_f = g + 0.08382d_1 + 0.3086(h-d_1) - \gamma$	$\Delta g_B = \Delta g_f - 0.04191d_1 - 0.1119(h-d_1)$
8	LAKE BOTTOM (below sea level) 	$\Delta g_f = g + 0.08382d_1 + 0.3086(h-d_1) - \gamma$	$\Delta g_B = \Delta g_f - 0.04191h - 0.06999(h-d_1)$

ANOMALY COMPUTATION CHART (p. 3)

Elev. Type Col. 21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
9	LAKE SURFACE (above sea level) with bottom below sea level 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.04191h - 0.06999(h-d_1)$
A	LAKE SURFACE (below sea level) 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.1119h + 0.06999d_1$ NOTE: d_1 = depth of lake positive downward
B	LAKE BOTTOM (surface below sea level) 	$\Delta g_f = g + 0.3086h - 0.2248d_1 - \gamma$ NOTE: d_1 = depth of lake positive downward	$\Delta g_B = \Delta g_f - 0.1119h + 0.06999d_1$
C	ICE CAP (bottom below sea level) 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.03843h - 0.07347(h-d_1)$ NOTE: d_1 = depth of ice positive downward

ANOMALY COMPUTATION CHART (p. 4)

Elev. Type Col. 21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
D	ICE CAP (bottom above sea level) 	$\delta g_f = g + 0.3086h - Y$	$\delta g_B = \delta g_f - 0.03843d_1 - 0.1119(h-d_1)$ NOTE: d_1 = depth of ice