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## 石油物探测量规范

Specification for surveying in petroleum geophysical exploration

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## 前 言

本标准是由以下六个测量标准合并修订而成，它们是：

- SY/T 5171—1999 《石油物探测量规范》；
- SY/T 5927—2000 《石油物探全球定位系统（GPS）测量规范》；
- SY/T 6291—1997 《石油物探全球卫星定位系统动态测量技术规范》；
- SY/T 5775—2002 《山区地震勘探测量技术规程》；
- SY/T 5828—1999 《石油物探测量成果质量检查验收细则》；
- SY/T 5931—2000 《测量仪器的使用与维护》。

本标准自发布之日起，同时代替上述六个石油物探测量标准。

同上述标准相比，本标准突出了下列两个方面的内容：

- 新技术和常用技术。本标准用了较大篇幅叙述 GPS 测量技术，而对于常规测量则进行较大幅度的精简。
- 作业方法和技术要求。本标准用了较大篇幅叙述石油物探测量作业方法和技术要求，而对于测量仪器的使用和维护的内容进行较大幅度精简。

本标准广泛吸收了国外油公司同类技术规定的内容，使之充分与国际测量技术接轨，同时满足国内、外生产施工的需要。

本标准的附录 A、附录 F 是规范性附录，附录 B、附录 C、附录 D、附录 E、附录 G、附录 H、附录 I、附录 J 是资料性附录。

本标准由石油物探专业标准化委员会提出并归口。

本标准起草单位：中国石油集团东方地球物理勘探有限责任公司测绘工程中心。

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本标准以中文和英文两种文字出版。当英文和中文两种版本有歧义时，以中文版本为准。

# 石油物探测量规范

## 1 范围

本标准规定了石油物探测量的工作方法和技术要求。

本标准适用于陆上石油物探测量工作。

## 2 规范性引用文件

下列文件中的条款通过本标准的引用而成为本标准的条款。凡是注明日期的引用文件，其随后所有的修改单（不包括勘误的内容）或修订版均不适用于本标准，然而，鼓励根据本标准达成协议的各方研究是否可使用这些文件的最新版本。凡是不注明日期的引用文件，其最新版本适用于本标准。

GB/T 18314—2001 全球定位系统（GPS）测量规范

## 3 术语和定义

下列术语和定义适用于本标准。

### 3.1

**石油物探测量** surveys in the petroleum geophysical exploration

为配合石油地球物理勘探工作所做的测量工作的统称。

### 3.2

**常规测量** conventional survey

使用经纬仪、测距仪、全站仪等测量仪器所进行的测量工作的统称，以区分卫星定位测量。

### 3.3

**物理点** geophysical point

地震勘探中的接收点、激发点以及非地震勘探中的各种观测点的统称。

### 3.4

**观测时段** observation session

接收机在测站上从开始到停止接收卫星信号连续工作的时间段。

### 3.5

**同步观测** simultaneous observation

两台或两台以上接收机同时对同一组卫星进行的观测。

### 3.6

**同步环** simultaneous loops

三台或三台以上的接收机同步观测所获得的基线向量构成的闭合环。

### 3.7

**异步环** unsimultaneous loops

由非同步观测获得的基线向量构成的闭合环。

### 3.8

**天线高** antenna height

观测时接收机天线相位中心到测站中心标志面的高度。

### 3.9

#### **基线解算 baseline solution**

求解两个同步观测的测站之间坐标差的过程。

### 3.10

#### **坐标转换参数 coordinates transformation parameters**

表达两个坐标系之间相互转换的数学关系所必需的若干参数的统称。

### 3.11

#### **参考站 reference station**

在一定的观测时间内，一台或几台接收机分别固定在一个或几个测站上，一直保持跟踪观测卫星，其余接收机在这些测站的一定范围内流动设站作业，这些固定测站称为参考站。

### 3.12

#### **流动站 roving station**

在参考站的一定范围内流动作业的接收机所设立的测站。

### 3.13

#### **实时差分测量 real time differential survey**

将参考站卫星定位接收机采集的数据，通过通讯链实时地传送给流动站卫星定位接收机，从而实时解算两站点的相对位置的测量方法；它包括实时相位差分测量（简称 RTK）和实时伪距差分测量（简称 RTD）。

### 3.14

#### **静态定位 static positioning**

通过多个测站上进行若干时段同步观测，确定测站之间相对位置的卫星定位测量。

### 3.15

#### **快速静态定位 fast static positioning**

利用快速整周模糊度解算法原理所进行的静态定位测量。

### 3.16

#### **电子手簿 electronic handbook**

能与测量仪器相互通讯并用于记录数据的电子设备。

## 4 总则

4.1 石油物探测量的任务是：依据物探设计，将物探测线的物理点采用一定的测量方法放样到实地，为物探野外施工、资料处理及解释提供符合要求的测量成果和图件。

4.2 凡国家级控制点或按照 GB/T 18314—2001、本标准第 6 章要求所布设的控制点均可作为石油物探测量起算的依据。所引用的控制点应经过可靠性检验。

4.3 物理点的平面坐标和高程的最终成果，采用 1954 年北京坐标系和 1956 年黄海高程系统；也可采用物探设计要求的坐标系。

4.4 石油物探成图比例尺小于 1:10 000 时，按高斯正形投影（TM 投影，中央子午线投影比例因子为 1）六度分带计算物理点的平面坐标；大于或等于 1:10 000 时，按高斯正形投影三度分带计算物理点的平面坐标。也可采用物探设计要求的投影和分带方式计算物理点的平面坐标。

4.5 导线测量、极坐标放样测量、实时差分测量和其他满足石油物探精度要求的测量方法均可用于物理点的放样测量；GPS 事后差分测量可用于地震勘探物理点偏移测量和非地震勘探测量。

4.6 在勘探成果图上，物理点相对于工区最近控制点平面位置中误差要求如下：

- a) 二维地震、重力、磁力、电法勘探不大于 0.4mm；
- b) 三维地震勘探不大于 0.2mm；

c) 化探不大于 1mm。  
物理点相对于工区最近控制点的高程中误差要求见表 1。

表 1 物理点高程中误差

项 目		比 例 尺			
		1:25 000	1:50 000	1:100 000	1:200 000
		中误差, m			
地 震		1.0	1.5	2.0	
重 力	平原、丘陵	0.2		0.4	0.8
	山地	0.4		0.7	1.2
磁力、化探		30.0			
电 法	大地电磁测深	5.0			
	连续电磁剖面法				
	建场测深法	20.0			

- 4.7 以两倍中误差作为本标准各项限差指标。
- 4.8 测线坐标方位角在  $45^{\circ} \pm 180^{\circ} \sim 135^{\circ} \pm 180^{\circ}$  之间 (含  $45^{\circ} \pm 180^{\circ}$ ,  $135^{\circ} \pm 180^{\circ}$ ) 为东西方向测线, 测线方位角在  $135^{\circ} \pm 180^{\circ} \sim 225^{\circ} \pm 180^{\circ}$  之间为南北方向测线。
- 4.9 物理点编号应与物探设计一致; 不能测量的物理点坐标可以通过内插求得, 但最终成果必须注有标记。
- 4.10 物理点的坐标和高程应实测, 地表平坦或起伏不大均等倾斜地区, 在满足物探精度的要求的情况下可进行内插。
- 4.11 二维地震测线相交时, 应进行交点检查:
- a) 联测物理点的点位误差: 当成图比例尺大于等于 1:25000 时, 不得大于成图比例尺的 0.2mm; 小于 1:25000 时, 不得大于成图比例尺的 0.1mm;
  - b) 联测物理点 (或室内计算的交点) 的高程较差, 在平坦地区不得大于 2m, 在山地、丘陵等地区不得大于 3m, 如超限则需做相应检核。
- 4.12 下列技术指标, 按技术设计和合同要求执行:
- a) 接收点、激发点点位的允许变通的范围;
  - b) 接收点距、激发点距及允许变通的范围;
  - c) 测线首尾满覆盖点坐标、首尾端点的实测坐标与设计坐标差值范围;
  - d) 勘探成图比例尺。
- 4.13 每段测线施测、计算完毕检查无误后, 应及时提供“测线合格通知书”、测线草图及物理点成果。测线合格通知书格式参见附录 B。
- 4.14 非地震物探测线布设要求:
- a) 电法测线一般按直线布设, 特殊地段按折线布设, 变通范围量不大于 20%。
  - b) 重力、磁力和化探测线一般布设成规则网状, 困难地区按物探要求确定每平方千米的最少物理点数。
  - c) 非地震勘探物理点可采用快速静态测量以及其他满足物探要求的测量方法布设, 技术及精度指标根据物探要求确定。
- 4.15 数据处理软件应经技术主管部门批准后才能使用。

5 准备工作

5.1 资料收集:

- a) 收集测区内的地形图、控制点成果、坐标转换参数、大地水准面资料及其他有关资料等;
- b) 收集与测区有关的行政区划图、交通图、气象资料、地下管线图及其他设施埋置图等资料;
- c) 收集已有的测线资料。

5.2 工区踏勘:

- a) 踏勘工区内控制点的位置, 检查控制点标志的稳定性及可靠性;
- b) 了解测区内地形、地物和行政管辖、工农业布局、人文交通、气象等情况;
- c) 会同物探、地质人员, 实地踏勘测线的位置和走向, 编写踏勘报告, 拟订施工方案和计划。

5.3 编写测量施工设计, 内容参见附录 C。

5.4 仪器设备的检验和检定: 检验可由仪器使用者进行, 检定应由法定的检测机构完成, 检定周期一般不超过一年。

6 控制测量

控制测量宜采用 GPS 控制网的方法, 也可采用控制导线的方法。

6.1 GPS 控制网

6.1.1 一般技术要求。

6.1.1.1 石油物探 GPS 网, 按精度划分为 I、II、III 三级, 见表 2。

表 2 石油物探 GPS 网的等级划分

级别	I	II	III
最大边长 km	≤400	≤200	≤30
平均边长 km	50≤S≤150	10≤S<50	3≤S<10
相对精度 ×10 <sup>-6</sup>	≤3	≤5	≤10

6.1.1.2 根据基线的长度与精度, 按表 3 和表 4 的要求确定观测时段长度及其他观测参数。

表 3 GPS 测量观测因素要求

方法	图形强度 PDOP	观测卫星数	采样率 s	卫星高度角 (°)
静态	≤8	≥4	1~60	≥12
快速静态	≤8	≥4	1~15	≥10

6.1.1.3 各级 GPS 网相邻弦长精度用式 (1) 表示, 并按表 5 执行:

$$\sigma = \sqrt{a^2 + (bd \times 10^{-6})^2} \dots\dots\dots (1)$$

式中:  
σ——标准差 (基线向量的弦长中误差), mm;

$a$ ——固定误差, mm;  
 $b$ ——比例误差系数;  
 $d$ ——相邻点间距离, km。

表 4 GPS 测量时段长度要求

方法	基线长度 km	单频接收机	双频接收机
		同步观测时段长 min	同步观测时段长 min
静态	$S < 20$	$\geq 45$	$\geq 30$
	$20 \leq S < 80$	$\geq 90$	$\geq 60$
	$80 \leq S < 200$	—	$\geq 120$
	$S \geq 200$	—	$\geq 150$
快速静态	$S \leq 20$	$\geq 10$	$\geq 5$

表 5 石油物探 GPS 网弦长误差要求

等级	I	II	III
固定误差 $a$ , mm	$\leq 5$	$\leq 10$	$\leq 10$
比例误差系数 $b$	$\leq 1$	$\leq 2$	$\leq 10$

- 6.1.1.4 GPS 测量大地高差的精度, 固定误差  $a$  和比例误差系数  $b$  按表 5 可放宽一倍执行。
- 6.1.1.5 在进行基线解算时, 对于长度小于 15km 的基线, 应求出双差固定解; 长度大于或等于 15km 的基线, 须在双差固定解和双差浮点解中取最优结果。
- 6.1.1.6 坐标转换参数应考虑与测区老资料的吻合并按下列优先顺序获取:
- a) 利用经有关部门鉴定, 在该工区准许使用的坐标转换参数;
  - b) 利用 GPS 控制网求取;
  - c) 单点定位确定坐标转换参数, 其单点定位观测时间不得少于 2 h。
- 6.1.1.7 利用坐标转换参数进行坐标转换后已知点坐标与网中同一已知点成果比较, 不同基线推算同一点坐标其点位较差应为:  $\Delta X \leq 0.5\text{m}$ ,  $\Delta Y \leq 0.5\text{m}$ ,  $\Delta H \leq 1.0\text{m}$ 。
- 6.1.1.8 坐标转换后的大地高应换算成海拔高, 公式为:

$$h = H - \xi \dots\dots\dots (2)$$

式中:  
 $H$ ——大地高, m;  
 $h$ ——海拔高, m;  
 $\xi$ ——高程异常值, m。

- 高程异常值应考虑与测区老资料的吻合并按下列优先顺序获取:
- 利用经有关部门鉴定, 在该工区准许使用的高程异常模型;
  - 利用数字化的高程异常图获取, 也可在比例尺大于或等于 1:2 500 000 的高程异常图上量取 (取至 0.1m);
  - 利用高程拟合的方法求取。

6.1.1.9 采用高程拟合方法求取 GPS 定位点的海拔高时, 已知高程控制点一般不少于 3 个。当已知



高程点数量少于 3 个，或分布不均匀时，应与附近高程控制点联测。

#### 6.1.2 布网方案的设计。

6.1.2.1 石油物探 GPS 网中，已知平面控制点数量应不少于 2 个；附近有水准点时，应将其纳入 GPS 网点，作为高程控制。

6.1.2.2 根据控制的范围和目的进行图上设计，已知点分布尽量均匀，如需水准高程联测，同时在图上设计出联测路线。

6.1.2.3 石油物探 GPS 网，可采用边连接、网连接、边点混合连接方式，网形应组成闭合、附合图形。特殊困难地区及精度要求允许情况下，可采用点连接。

#### 6.1.3 选点与埋石。

##### 6.1.3.1 选点时对点位的基本要求：

- a) 点位的选择应符合技术设计要求，并有利于其他测量手段进行扩展与联测；
- b) 点位交通方便，地面基础稳定，易于点的保存，便于接收设备安置和仪器操作，并应有利于安全作业；
- c) 视野开阔，视场周围  $10^\circ$  以上不宜有障碍物；
- d) 远离大功率无线电发射源（如电视台、微波站等）和高压输电线；
- e) 附近不应有强烈干扰卫星信号接收的物体，在大面积水域和浅海区域施工时宜采用防多路径效应的接收天线；
- f) 应充分利用符合上述要求的旧控制点及其标石。

6.1.3.2 GPS 标志可采用钢管、水泥桩或木桩，所有等级的 GPS 点应稳固并设立中心标志，中心标志的半径应小于 2mm。

6.1.3.3 I 级 GPS 网选点埋石后应提交 GPS 点之记和 GPS 网图，GPS 点之记格式参见附录 D。

#### 6.1.4 外业观测。

##### 6.1.4.1 观测计划：

- a) 进行 GPS 可见性预报，所采用的星历龄期不得超过 30d。预报表应包括可见卫星号、卫星高度角和方位角、最佳观测卫星组、最佳观测时段、点位几何图形因子等内容；
- b) 观测计划应包括观测时间、测站号、测站名称、采集参数及接收机号等。

##### 6.1.4.2 观测作业：

- a) 作业人员要严格按观测计划进行作业；
- b) 天线架设的对中误差不应大于 5mm；
- c) 架设有定向标志的天线时，应使天线的定向标志指向正北，误差在  $10^\circ$  以内；
- d) 每时段观测前后应分别量取 GPS 天线高，两次天线高互差不应大于 3mm；
- e) 一个观测时段过程中不得进行下列操作：关闭、重新启动接收机、进行自测试（发现故障时除外）、改变卫星截止高度角、改变数据采样间隔、改变天线的位置、按动关闭文件或删除文件的功能键；
- f) 正在工作的接收机附近，禁止使用对讲机、手机，雷雨过境时应关机停测，并卸下天线以防雷击；
- g) 观测作业过程中仔细填写记录，记录格式参见附录 E；
- h) 观测结束后应及时将接收机数据下装，做好数据备份；
- i) 定时检验和维护仪器，确保仪器的正常运转；仪器检验与维护见附录 F。

#### 6.1.5 数据处理。

##### 6.1.5.1 GPS 基线解算：

- a) 可采用卫星广播星历或精密星历作为基线解算起算值；
- b) 基线解算时应严格按技术设计的要求对基线观测质量进行检核：有效观测值的剔除率不应大

于 30%，基线解算精度应满足 6.1.1.1 和 6.1.1.3 的规定；

c) 复测基线的长度较差  $ds$ ，应满足式 (3) 的要求：

$$ds \leq 2\sqrt{2}\sigma \quad \dots\dots\dots (3)$$

#### 6.1.5.2 GPS 网闭合环的检核：

a) 同步环闭合差应满足：

$$\left. \begin{aligned} W_x &\leq \frac{\sqrt{n}}{5}\sigma \\ W_y &\leq \frac{\sqrt{n}}{5}\sigma \\ W_z &\leq \frac{\sqrt{n}}{5}\sigma \\ W &= \sqrt{W_x^2 + W_y^2 + W_z^2} \leq \frac{\sqrt{3n}}{5}\sigma \end{aligned} \right\} \dots\dots\dots (4)$$

b) 异步环闭合差应满足：

$$\left. \begin{aligned} W_x &\leq 3\sqrt{n}\sigma \\ W_y &\leq 3\sqrt{n}\sigma \\ W_z &\leq 3\sqrt{n}\sigma \\ W &\leq 3\sqrt{3n}\sigma \end{aligned} \right\} \dots\dots\dots (5)$$

式 (4) 和式 (5) 中： $W_x$ 、 $W_y$ 、 $W_z$  分别为  $x$ 、 $y$ 、 $z$  坐标分量闭合差， $W$  为环闭合差， $n$  为构成环的边数。

#### 6.1.5.3 GPS 网的平差计算：

- 各项质量检验符合要求后，应以所有基线组成闭合图形，以三维基线向量及其相应方差协方差阵作为观测信息，以一个点的 WGS-84 坐标作为起算数据，进行 GPS 网的无约束平差。
- 在无约束平差确定的有效观测量的基础上，进行三维约束平差或二维约束平差；约束点的已知坐标、已知距离或已知方位，可作为强制约束的固定值，也可作为加权观测值；
- 无约束平差中，基线向量的改正数 ( $V_{\Delta X}$ 、 $V_{\Delta Y}$ 、 $V_{\Delta Z}$ ) 绝对值应满足式 (6) 要求：

$$\left. \begin{aligned} V_{\Delta X} &\leq 3\sigma \\ V_{\Delta Y} &\leq 3\sigma \\ V_{\Delta Z} &\leq 3\sigma \end{aligned} \right\} \dots\dots\dots (6)$$

- 约束平差中，基线向量的改正数与剔除粗差后的无约束平差结果的同名基线相应改正数的较差 ( $dV_{\Delta X}$ 、 $dV_{\Delta Y}$ 、 $dV_{\Delta Z}$ ) 应符合式 (7) 要求：

$$\left. \begin{aligned} dV_{\Delta X} &\leq 2\sigma \\ dV_{\Delta Y} &\leq 2\sigma \\ dV_{\Delta Z} &\leq 2\sigma \end{aligned} \right\} \dots\dots\dots (7)$$

#### 6.1.6 重测和补测：

- 未按施测方案要求，外业缺测、漏测或数据处理后观测数据不满足 6.1.5.1，6.1.5.2 和 6.1.5.3 的要求，有关成果应及时重测或补测；
- 重测或补测的分析应写入数据处理报告。

#### 6.1.7 编写 GPS 控制测量报告，格式参见附录 G。

### 6.2 导线控制测量

#### 6.2.1 导线控制测量应采用附和导线形式进行布设，各项限差要求见表 6。

表 6 控制导线的主要技术要求

项 目		限 差	备 注
导线精度	导线总长, km	40	三维测线施工时导线长度减半
	方位角闭合差, (″)	$40 \sqrt{N}$	$N$ 为测站数
	全长相对精度	1/5000	当导线全长小于 10 km 时, 按 10 km 计算
	高程闭合差, m	$0.20 \sqrt{S}$	$S$ 为导线全长, 以 km 为单位
观测限差	两倍照准差互差, (″)	45	
	指标差互差, (″)	45	
	水平角测回间较差, (″)	30	
	测距较差, m	0.03	
	直反视高差较差, m	0.3L	导线边长小于 0.3km 时, 按 0.3km 计算直视、反视高差的限差; $L$ 单位为 km

6.2.2 导线观测技术要求。

6.2.2.1 边长测量:

- a) 导线边长采用测距仪进行测定, 观测时野外应进行加常数、乘常数和气象改正及仪器说明书规定的其他改正;
- b) 单视测定两次, 读数精确到 0.001m , 取算术平均值;
- c) 导线最大边长不应大于 2km。

6.2.2.2 角度测量:

- a) 水平角、天顶距采用 J2 级经纬仪 (或测角中误差不低于 3″ 的全站仪) 两测回测定;
- b) 水平角、天顶距观测限差见表 6。

6.2.2.3 仪器高、觇标高量取精确至 0.001m。

6.2.2.4 导线的起、闭点可采用国家等级控制点、GPS 静态或快速静态定位点。

7 物理点布设

7.1 物理点坐标与高程的测定方法:

- a) 导线测量;
- b) 极坐标放样测量;
- c) 导线结合极坐标放样测量;
- d) 实时差分测量;
- e) 极坐标放样与实时差分联合测量;
- f) 静态测量;
- g) 其他能满足物探精度要求的测量方法。

7.2 导线测量。

7.2.1 导线布设形式:

- a) 附和导线;
- b) 闭合导线;
- c) 支导线。

7.2.2 导线各项限差见表 7、表 8 和表 9。在山区等特殊地区导线总长度可延长, 地震勘探成图比例尺大于或等于 1:25 000 时可延长 50%; 导线长度小于 10km 时, 按 10km 计算导线限差。

表 7 导线主要技术指标

成图比例尺	导线总长度 km	全长相对精度	方位角闭合差 (")	高程闭合差 m
1:10 000	15	1/3 000	$60 \sqrt{N}$	$0.40 \sqrt{S}$
1:25 000	20			
1:50 000	30	1/2 500		
1:100 000	40			
注：N 为测站数；S 为导线长度，单位为 km。				

表 8 水平角、天顶距观测值限差

仪器等级	两倍照准差互差 (2C 差互差)	指标差互差
J2 级	$\pm 45''$	$\pm 45''$
J6 级	$\pm 60''$	$\pm 60''$

表 9 支导线

成图比例尺	支导线长度, km
1:10 000	1
1:25 000	
1:50 000	3
1:100 000	

7.2.3 导线观测技术要求。

7.2.3.1 边长测量：

- a) 导线边长测定方法参见 6.2.2.1 a)；
- b) 单视测定两次，读数精确到 0.01m，两次互差不应大于 0.05m，取算术平均值；
- c) 导线最大边不应大于 2km，山区等困难地区可放宽到 4km。

7.2.3.2 角度测量：

- a) 水平角和天顶距采用测角中误差不低于 6" 的经纬仪或全站仪一测回测定；
- b) 同一测站内水平角、天顶距观测限差见表 8。

7.2.3.3 高程测量：

- a) 采用直视、反视观测，直视、反视高差较差的限差按  $0.4L$  计算，导线边长小于 0.5km 时，按 0.5km 计算直视、反视高差的限差， $L$  单位为 km，计算结果单位为 m。
- b) 仪器高、觇标高量取精确至 0.01m。

7.2.3.4 野外改正。

- 以下几项改正应尽量在野外现场进行：
- a) 距离投影到大地水准面上的改正；
  - b) 距离归算到高斯平面上的改正；
  - c) 地球曲率与大气折光差的改正。

7.2.3.5 导线的起、闭点可采用国家等级控制点、控制导线点、GPS 静态或快速静态定位点以及经检核的 RTK 点。

7.2.3.6 导线起、闭方位可采用两控制点反算，也可采用天文方位测量。

7.2.3.6.1 天文方位测量可采用下列方法：

- a) 太阳高度法；
- b) 北极星任意时角法；
- c) 太阳任意时角法。

7.2.3.6.2 天文方位测量观测的要求：

- a) 方位角观测不少于三个测回，每测回观测时间不应超过 10min；
- b) 观测之日，时间必须与地方时间进行校对，测定表差，温度测定到度；
- c) 测定太阳方位角时，太阳高度角不得小于  $8^\circ$ ，采用太阳高度法时一般不得在地方时间 10 时至 14 时观测；
- d) 各测回算得的坐标方位角值，其互差不得大于  $1'$ ，取算术平均值作为最后成果。

7.3 物理点极坐标放样。

7.3.1 物理点的坐标、高程采用单视半测回测定，可与导线测量同时进行，半测回归零限差为  $30''$ 。

7.3.2 野外改正参见 7.2.3.4。

7.3.3 重测与补测：测站及物理点资料不符合要求，当站发现的当站补测，资料处理时发现的必须重新设站进行观测。

7.3.4 复测。

7.3.4.1 有下列情况之一时，应复测 2 个以上物理点或复测 2 次单个控制点进行检核后才能进行施工：

- a) 迁站后；
- b) 后视方向改变；
- c) 重新对中整平；
- d) 关机后重新开机。

7.3.4.2 每条（束）测线的复测率应达到该测线物理点数的 1%。

7.3.4.3 复测检核限差： $\Delta x \leq 0.6\text{m}$ ， $\Delta y \leq 0.6\text{m}$ ， $\Delta h \leq 1.0\text{m}$ 。

7.4 根据施工方法和测量仪器，可采用人工记录和电子记录。

7.4.1 人工记录应该真实、准确、字迹清楚，各项注记应填写齐全。正确完成本站的各项计算工作后方可迁至下一站。

7.4.2 电子记录的原始数据应有数据保护措施。

7.5 导线测量与极坐标放样测量数据处理。

7.5.1 导线可采用简易平差方法计算，角度按测站数配赋，坐标、高程按边长比例配赋。

7.5.2 若野外施工中未按照 7.2.3.4 进行三项改正，应在成果计算时加入。

7.5.3 计算所用的原始记录及起算数据，均应经检查核对后才能使用。

7.5.4 磁卡、电子手簿或仪器内存记录的原始数据，按下列原则进行编辑：

- a) 点号及站点关系记错可以进行编辑，原始数据中的角度、边长等观测值在任何情况下不能进行编辑，仪器高、觇标高可参照野外手簿进行编辑修改；
- b) 同一测站中要删除同名、错误、多余的数据；
- c) 多条导线重复部分，可将重复部分拷贝后同非重复部分组成完整的导线。

7.5.5 数据处理过程中应有数据跟踪处理备忘录。

7.5.6 数据处理中，数字取值精度要求应符合下列规定：

- a) 距离、坐标和高程取值至 0.01m；
- b) 水平角、天顶距观测值和方位角取值至  $1''$ 。

7.6 实时差分测量放样。

### 7.6.1 参考站。

7.6.1.1 放样用的参考站可以建立在已布设的控制点上，也可利用其他经检核的差分参考站进行放样（检核限差参考 7.6.1.3 执行）。

7.6.1.2 采用实时差分测量与极坐标放样测量共同布设物理点时，实时相位差分测量布设的有固定标记的物理点可作为导线的起、闭点，导线点不能作为参考站。

#### 7.6.1.3 参考站的发展：

- a) 参考站连续发展不应超过 3 次；
- b) 参考站距离控制点累计基线长度不应超过 50km；
- c) 每次发展的参考站都应该进行检核：
  - 检核对象：参考站或由该参考站所测的有固定标记的物理点；
  - 检核方法：静态测量、快速静态测量及实时差分测量；
  - 检核限差： $\Delta x \leq 0.2\text{m}$ ， $\Delta y \leq 0.2\text{m}$ ， $\Delta h \leq 0.4\text{m}$ 。

### 7.6.2 流动站：

- a) 流动站距参考站的距离一般不超过 20km；
- b) 流动站天线稳定后方可记录实时点位信息。

### 7.6.3 复测检核。

7.6.3.1 实时差分测量有下列情况之一时，应复测 2 个以上物理点或复测 2 次单个控制点进行检核后才能进行施工：

- a) 每日施工前；
- b) 搬迁至新的参考站；
- c) 接收机或手簿内的数据或参数更新后。

7.6.3.2 每条（束）测线的复测率应达到该测线物理点数的 1%。

7.6.3.3 每条二维测线的端点应作静态或快速静态检核。

#### 7.6.3.4 复测检核限差如下：

- a) 实时相位差分测量： $\Delta x \leq 0.6\text{m}$ ， $\Delta y \leq 0.6\text{m}$ ， $\Delta h \leq 1.0\text{m}$ ；
- b) 实时伪距差分测量： $\Delta x \leq 1.0\text{m}$ ， $\Delta y \leq 1.0\text{m}$ ， $\Delta h \leq 1.5\text{m}$ ；
- c) 事后差分测量： $\Delta x \leq 1.5\text{m}$ ， $\Delta y \leq 1.5\text{m}$ ， $\Delta h \leq 1.5\text{m}$ 。

### 7.6.4 实时差分测量数据处理。

7.6.4.1 对原始记录要适时下装、备份，以防丢失。

7.6.4.2 当天数据当天处理，发现漏点或超限点要及时补测、重测，并作好备忘录。

7.6.4.3 流动站的 GPS 高程向海拔高程转换中，其高程异常值可按下列顺序优先获取：

- a) 利用经有关部门鉴定，在该工区准许使用的高程异常模型；
- b) 利用数字化的高程异常图获取，也可在比例尺大于或等于 1:2 500 000 的高程异常图上量取（取至 0.1m）；
- c) 利用高程拟合的方法求取；
- d) 当参考站到流动站的高程异常差不大于 0.5m 时，通过参考站的高程异常值对流动站的大地高进行改正。

## 8 资料整理

每期施工完毕后应进行资料整理，资料整理分为硬拷贝资料和电子资料。

### 8.1 硬拷贝资料。

#### 8.1.1 内容：

- a) 施工设计；

- b) 施工总结，格式参见附录 H；
- c) GPS 控制测量报告；
- d) 物理点测量成果簿；
- e) 物探测量质量统计簿。

8.1.2 物探测量成果整理内容及装订顺序。

8.1.2.1 二维测线物理点测量成果簿：

- 封面；
- 副封面；
- 目录；
- 技术说明；
- 起算数据；
- 首尾接收点、一次覆盖点、激发点、满覆盖点成果；
- 物理点成果；
- 接收点空点表；
- 测线位置图。

8.1.2.2 三维测线物理点测量成果簿：

- 封面；
- 副封面；
- 目录；
- 技术说明；
- 起算数据；
- 三维施工面积、边界拐点坐标；
- 三维偏前满覆盖面积、边界拐点坐标；
- 三维一次覆盖面积、边界拐点坐标；
- 物理点成果；
- 接收点空点表；
- 恢复性激发点成果；
- 测线位置图。

8.1.2.3 物探测量质量统计簿：

- 封面；
- 目录；
- 甲方验收意见；
- 乙方验收意见；
- 技术说明；
- 地震测线质量统计表；
- 导线测量质量统计表；
- 二维（三维）测线端点实测坐标与设计坐标较差统计表；
- 二维测线交点计算表；
- 二维测线交叉联测检核质量统计表；
- 物理点复测检核质量统计表；
- 测线位置图。

8.2 电子资料应包括以下内容：

- a) 物理点测量原始记录、卫星定位测量原始记录；

- b) 物理点测量成果数据（跨越两投影带的测线要有两个带的物理点成果），存盘格式参见附录 I；
- c) 地震测线质量统计数据，有关格式参见附录 J：
  - 地震测线质量统计表；
  - 导线测量质量统计表；
  - 控制点成果表；
  - 二维（三维）测线端点实测坐标与设计坐标较差统计表；
  - 二维测线交点计算表；
  - 二维测线交叉联测检核质量统计表；
  - 物理点复测检核质量统计表；
  - 物理点实测坐标与设计坐标较差统计表；
  - 测线位置图。
- d) 资料的解释性文件。

## 9 资料验收

### 9.1 检查项目

- 9.1.1 仪器检定合格证书。
- 9.1.2 原始资料：
  - a) 起算数据；
  - b) 原始记录。
- 9.1.3 GPS 控制测量：
  - a) 选点和埋石；
  - b) 联测的控制点；
  - c) 观测时段的长度；
  - d) GPS 网平差方法和各项精度；
  - e) 参数的选择、解算、使用方法；
  - f) 高程异常改正或高程拟合；
  - g) 提供成果的坐标系统、高程系统、投影方式及投影带号。
- 9.1.4 天文方位：
  - a) 观测方法、高度角、观测时间、测回数；
  - b) 各测回方位角较差。
- 9.1.5 导线：
  - a) 导线的选点、布设和连接方式；
  - b) 测回数、边长、导线长度、支导线长度、方位角闭合差、高程闭合差、导线全长相对精度。
- 9.1.6 物理点的放样及施测：
  - a) 放样方法、精度、点距、点位偏移；
  - b) 物理点点位中误差、高程中误差；
  - c) 物理点野外复测率、复测精度。
- 9.1.7 硬拷贝资料：
  - a) 物探资料处理、解释所要求的各项测量成果、图件；
  - b) 成果簿及质量统计簿的装订格式。
- 9.1.8 电子资料：
  - a) 数据存盘格式；



- b) 电子资料中提供的数据;
- c) 电子资料与硬拷贝资料是否一致。

## 9.2 成果质量评定

由生产技术部门对测量成果质量按合格、不合格两级进行评定。

### 9.2.1 全部符合下列要求为合格品:

- 野外原始记录清楚、齐全、真实可靠;
- 导线各项误差及精度指标符合规范要求;
- 测线位置满足物探技术要求;
- 放样误差超过规定范围的物理点数不大于物理点总数的 2%;
- 点距误差超过规定范围的物理点数不大于物理点总数的 2%;
- 物理点复测率、点位中误差和高程中误差在规范的范围之内;
- 所提交项目齐全、准确。

### 9.2.2 有下列情况之一的为不合格品:

- 导线各项误差及精度指标有一项不符合要求;
- 测线位置、长度不满足物探技术要求;
- 放样误差超过规定范围的物理点数大于物理点总数的 2%;
- 点距误差超过规定范围的物理点数大于物理点总数的 2%;
- 物理点复测率、点位中误差和高程中误差超过规范的范围。

## 9.3 验收意见书

对施工方法、各施工环节质量及最终成果给予明确的结论,指出存在的问题并提出整改意见。验收意见书内容包括:

- a) 工作概述。
- b) 检查验收的依据。
- c) 任务完成情况:
  - 测线长度;
  - 满覆盖长度;
  - 激发点、接收点实测点数及空点数;
  - 野外实地检核情况。
- d) 质量情况:
  - 测线位置的准确性;
  - 点位中误差、高程中误差;
  - 其他各项技术指标。
- e) 资料整理情况:
  - 硬拷贝资料;
  - 电子资料。
- f) 结论。

附 录 A  
(规范性附录)  
大地坐标系有关说明

### A.1 WGS-84 大地坐标系的地球椭球基本参数及主要几何和物理常数

#### A.1.1 地球椭球基本参数:

长半径  $a = 6\,378\,137\text{ m}$

地球引力常数 (含大气层)  $GM = 3\,986\,005 \times 10^8 \text{ m}^3 \cdot \text{s}^{-2}$

正常化二阶带谐系数  $C_{2,0} = -484.166\,85 \times 10^{-6}$

地球自转角速度  $\omega = 7\,292\,115 \times 10^{-11} \text{ rad} \cdot \text{s}^{-1}$

#### A.1.2 主要几何和物理常数:

短半径  $b = 6\,356\,752.3142\text{ m}$

扁率  $\alpha = 1/298.257\,223\,563$

第一偏心率平方  $e^2 = 0.006\,694\,379\,990\,13$

第二偏心率平方  $e'^2 = 0.006\,739\,496\,742\,227$

椭球正常重力位  $U_0 = 62\,636\,860.849\,7 \text{ m}^2 \cdot \text{s}^{-2}$

赤道正常重力  $\gamma_0 = 9.970\,326\,771\,4 \text{ m} \cdot \text{s}^{-2}$

A.1.3 WGS 84 (G730) 大地坐标系  $GM = 3\,986\,004.418 \times 10^8 \text{ m}^3 \cdot \text{s}^{-2}$ , 其他地球椭球基本参数及主要几何和物理常数同 A.1.1 和 A.1.2。

### A.2 1980 西安坐标系的参考椭球基本参数及主要几何和物理常数

#### A.2.1 参考椭球基本参数:

长半径  $a = 6\,378\,140\text{ m}$

地球引力常数 (含大气层)  $GM = 3\,986\,005 \times 10^8 \text{ m}^3 \cdot \text{s}^{-2}$

二阶带谐系数  $J_2 = 1\,082.63 \times 10^{-6}$

地球自转角速度  $\omega = 7\,292\,115 \times 10^{-11} \text{ rad} \cdot \text{s}^{-1}$

#### A.2.2 主要几何和物理常数:

短半径  $b = 6\,356\,755.288\,2\text{ m}$

扁率  $\alpha = 1/298.257$

第一偏心率平方  $e^2 = 0.006\,694\,384\,999\,59$

第二偏心率平方  $e'^2 = 0.006\,739\,501\,819\,47$

椭球正常重力位  $U_0 = 6\,263\,683 \times 10 \text{ m}^2 \cdot \text{s}^{-2}$

赤道正常重力  $\gamma_0 = 9.780318 \text{ m} \cdot \text{s}^{-2}$

### A.3 1954 年北京坐标系参考椭球的基本几何参数

长半径  $a = 6\,378\,245\text{ m}$

短半径  $b = 6\,356\,863.018\,8\text{ m}$

扁率  $\alpha = 1/298.3$

第一偏心率平方  $e^2 = 0.006\,693\,421\,622\,966$

第二偏心率平方  $e'^2 = 0.006\,738\,525\,414\,683$

**附 录 B**  
**(资料性附录)**  
**测线合格通知书格式**

施工单位:

施工日期：从\_\_\_\_\_年\_\_\_\_月\_\_\_\_日至\_\_\_\_\_年\_\_\_\_月\_\_\_\_日

\_\_\_\_\_地区\_\_\_\_\_测线(束), 测线长度\_\_\_\_\_ km, 桩号从\_\_\_\_\_至\_\_\_\_\_; 物理点共计\_\_\_\_\_个, 其中接收点\_\_\_\_\_个, 激发点\_\_\_\_\_个, 接收点空点\_\_\_\_\_个; 经室内计算和展点检查, 各项精度指标均符合测量规范和物探设计要求, 准予施工。

备注:

(填写接收点空点、恢复性激发点桩号)

计算员签名: \_\_\_\_\_ 年 \_\_\_\_ 月 \_\_\_\_ 日  
测量组长签名: \_\_\_\_\_ 年 \_\_\_\_ 月 \_\_\_\_ 日  
队经理签名: \_\_\_\_\_ 年 \_\_\_\_ 月 \_\_\_\_ 日

**附 录 C**  
**(资料性附录)**  
**测量施工设计**

测量施工设计应包括以下内容。

**C.1 概述**

- 任务来源、合同号及测线分布情况及工作量；
- 测区概况。

**C.2 施工方案**

- 施工方法；
- 加密控制点计划；
- 物探测线施工计划等。

**C.3 技术依据**

- 依据的测量标准；
- 测量成果的坐标系统、高程系统、投影方式及勘探成图比例尺。

**C.4 技术要求**

**C.4.1 物探对测量技术要求**

- 接收点、激发点点位的允许变通的范围；
- 接收点距、激发点距及允许变通的范围；
- 二维测线端点的实测坐标与设计坐标的差值允许变通的范围；
- 三维接收点、激发点的实测坐标与设计坐标的差值允许范围，相邻接收点间、激发点间距离误差允许范围；
- 空点、加密、恢复性激发点的技术要求；
- 二维测线偏移、满覆盖点、接收点及测线交点误差允许范围和允许变通的范围；
- 物探对测量的其他技术要求。

**C.4.2 测量技术要求**

- 控制测量方法及技术要求；
- 坐标转换参数的来源；
- 本地区海拔高程的转换方法及技术要求；
- 物理点实测方法、技术要求及精度指标。

**C.5 人员与装备**

- 计划投入的人员及数量；
- 仪器类型、型号、数量。

**C.6 质量保证措施**

- 影响测量施工及成果质量的主要因素及质量保证措施；
- 测量标志埋置及保护措施。

**C.7 设计测线位置**

- 二维地震测线的起、止点号，设计坐标、方位、测线长度等；
- 三维地震测网起算坐标原点、测线设计方位、施工边界、一次覆盖边界、满覆盖边界及线束关系、接收线和激发线起止桩号等。

**C.8 资料处理与上交**

**C.9 HSE 管理措施**

附 录 D  
(资料性附录)  
GPS 点之记格式

日期：\_\_\_\_年\_\_\_\_月\_\_\_\_日      记录者：\_\_\_\_绘图者：\_\_\_\_校对者：\_\_\_\_

点名及种类	GPS点	名		土 质	
		号			
	相邻点（名、号、里程、通视否）			标石说明（单层/双层、类型、新点/旧点）	
所在地					
交通路线					
所在图幅号			概略位置	X	Y
				L	B
(略图)					
备注					

附 录 E  
(资料性附录)  
GPS 外业观测记录格式

项目 GPS 外业观测记录	
观测者姓名_____	日 期_____年__月__日
测 站 名_____	测 站 号_____
天 气 状 况_____	时 段 号_____
测站近似坐标：  纬度：_____°_____' 经度：_____°_____' 高程：_____m	本点为： <input type="checkbox"/> _____新点 <input type="checkbox"/> _____等大地点 <input type="checkbox"/> _____等水准点 <input type="checkbox"/> _____
记录时间 _____ 北京时间 <input type="checkbox"/> UTC <input type="checkbox"/> 时区	开录时间 _____ 结束时间 _____
接收机号 _____ 天线高：_____m 测前量高 1. _____ 2. _____	天线号 _____ 测后校核值：_____m 测前平均值 _____m
天线高量取方式略图	测站略图及障碍物情况
备注	

**附录 F**  
**(规范性附录)**  
**测量仪器检验与维护**

**F.1 光学经纬仪和红外测距仪的维护**

**F.1.1 一般应注意下列几点：**

- a) 仪器安置于三脚架上，应有专人看护，防止行人、车辆等损坏仪器；
- b) 仪器应避免日晒、雨淋，在强光或有雨露下作业，应撑伞遮挡；
- c) 受潮仪器回驻地后应在通风干燥处开箱晾干；
- d) 仪器箱严禁坐人；
- e) 严禁将测距仪对太阳观测，测太阳方位角时应将测距头卸下或用深度滤光镜（电焊墨镜片类）盖住发射、接收镜头。

**F.1.2 仪器的运输与保管一般应做到以下几点：**

- a) 每日出工、收工或迁站应有专人负责；
- b) 长途运输时要有防震箱安放仪器并盖有遮雨布，装车时仪器务必正放，不得倒置，并有专人押运；
- c) 仪器存放在通风、干燥、温度稳定的房间内，仪器不得靠近火炉或暖气管道；
- d) 若仪器长期不使用，要定期保养。

**F.2 全站仪的维护**

**F.2.1 电源的维护：**

- a) 在主机（全站仪主机、计算机等）处于关闭状态下插、拔电源插头及数据接口；
- b) 每年度（期）施工完毕或仪器长时间不使用时，应将电池从仪器中取出；
- c) 非施工期间的电池保养、通电周期、保养环境按仪器厂商提供的说明书要求执行；
- d) 电源插头及插座要保持清洁。

**F.2.2 主机的维护：**

- a) 望远镜未加盖太阳滤光镜不得直接照准太阳；
- b) 在强光、雨天及潮湿空气中作业时，应给仪器撑伞；
- c) 作业中停止使用仪器时，应盖上镜头盖，罩上仪器罩；
- d) 作业中仪器发出警告信号，应停止观测，并根据提示查找原因；
- e) 有闪电、雷击时应关闭主机停止观测；
- f) 不应将仪器箱作为坐、垫工具；
- g) 用柔软毛刷清扫仪器灰尘，镜头有污物时，用仪器附属镜头刷擦去灰尘；
- h) 严禁用有机溶液擦拭显示窗、键盘及运输箱；
- i) 若仪器被水淋湿，应将其擦干，并增加仪器箱中干燥剂数量；
- j) 仪器长途搬运时应做到：主机放入仪器箱前将内部电池从仪器支架上取下，将仪器及附件箱放入特制的防震箱内。

**F.2.3 附件的维护：**

- a) 随时检查三脚架螺丝，发现松弛现象立即紧固；
- b) 随时检查棱镜固定螺丝；
- c) 保持棱镜镜面清洁；



- d) 随时检查棱镜基座螺丝，长途搬运时应紧固三角基座锁紧螺丝。

### F.3 GPS 接收机的检验与维护

GPS 接收设备的全面检验一般包括一般检视和通电检验。

#### F.3.1 一般检视包括：

- a) 接收机及天线的外观是否良好；
- b) 各部件、附件、其他辅助设备以及使用手册等是否完好、齐全；
- c) 各紧固部件有无松动或脱落。

#### F.3.2 通电检验包括：

- a) 用连接电缆将接收机与电源正确接合，然后打开接收机开关；
- b) 通电检验内容有：通电后有关信号灯、按键、显示系统以及仪表工作是否正常；利用自测试命令进行测试。

#### F.3.3 接收机经过检修或更换插板（插件）后，应重新进行检定。

#### F.3.4 各作业单位应建立设备检验的资料档案，记录历次检验结果以及设备使用情况，以便掌握每台设备的质量和和使用状况。

#### F.3.5 接收机运输注意事项：

- a) 无论采取何种运输方式，均需装入箱套，必须轻拿轻放，不可碰撞、倒置和重压，并要有专人押运；
- b) 托运时，接收机应放置妥当，要防止运输工具起动、刹车、转弯等因素造成的碰撞和倾倒；
- c) 当由专用车长途搬运时，必须装入箱套，箱体应与周围车身系紧，同时，驾驶员还应根据路面条件掌握车速，避免剧烈震动；
- d) 天线装箱装车时，要避免与金属体接触，电缆要避免同刀斧或其他刃器接触。

#### F.3.6 接收机保管的要点：

- a) GPS 接收机要有专人保管；
- b) 接收机不用时，应用软布、毛刷清洁设备各部分，放在带有软垫的箱内，要防震、防潮、防晒、防尘；
- c) 接收机放在通风、干燥、温度稳定的房间内，不得靠近火炉或暖气片等热源；
- d) 接收机在室内存放期间，应隔 1~2 月通电检查一次，仪器按规定充电；
- e) 长时间在野外使用的天线电缆，应半年测试一次；
- f) 严禁随意拆卸仪器各部件，如发生故障，应认真记录有关情况，交专业人员维修。

**附 录 G**  
**(资料性附录)**  
**GPS 控制测量报告**

GPS 控制测量报告一般包括以下内容：

- a) 任务来源，测区已有测量资料概况，项目名称，施测目的和基本精度要求；
- b) 测区范围与位置，自然地理条件，气候特点，交通及电讯、供电等情况；
- c) 施测单位，施测起始时间，作业人员数量，技术状况；
- d) 作业技术依据；
- e) 作业仪器类型、精度及检验和使用情况；
- f) 选点和埋石情况；
- g) 观测方法及补测重测情况，以及野外作业发生问题的说明；
- h) 外业观测数据质量分析与野外数据检核情况；
- i) 数据处理方案、所采用的软件、所采用的星历、起算数据、坐标系统，以及无约束平差、约束平差情况；
- j) 误差检验及相关参数和平差结果的精度估计等；
- k) 坐标转换和高程转换的说明；
- l) 拟合或转换控制点海拔高程检验情况；
- m) 坐标参数解算情况；
- n) 上交成果中尚存问题和需要说明的其他问题、建议或改进意见；
- o) 各种附表和附图；
- p) 测量成果简要列表。

**附 录 H**  
**(资料性附录)**  
**测量施工总结**

每年（期）施工结束，参照下列项目编写施工总结报告。

**H.1 概述**

- a) 任务来源、合同号；
- b) 测区位置、范围、行政隶属关系；
- c) 测区自然地理特征、交通状况、气候特征和困难类别。

**H.2 任务完成情况**

- a) 施工起止日期；
- b) 布设控制点数；
- c) 完成测线长度、物理点数。

**H.3 作业技术依据**

**H.4 施工过程**

- a) 控制点布设情况；
- b) 施工作业方法；
- c) 施工组织情况；
- d) 设备投入情况；
- e) 数据处理情况；
- f) 施工中存在的问题和解决方案。

**H.5 施工质量**

- a) 导线精度及最弱点误差分布情况；
- b) 物理点放样误差分析；
- c) 物理点复测检核情况；
- d) 交点计算或联测情况；
- e) 测线端点（含三维边界拐点）实测坐标与设计坐标较差情况；

**H.6 HSE 执行情况**

**H.7 资料上交情况**

**H.8 结论和建议**

附 录 I  
(资料性附录)  
物探测量成果存盘数据格式

I.1 总则

地震测线上物理点的坐标和高程可通过在实测点之间内插来确定。点文件包含所有物理点（实测的和内插得到的）和永久标志点的坐标和高程。激发点文件是按照时间顺序排列的，而接收点文件是按照测线号、点号和索引号升序排列的。为避免任何可能出现的混乱现象，每个野外物理点（激发点或接收点）的位置，必须保持其唯一的名称。

I.1.1 数据记录技术规格：

- a) 一个测量 SPS 数据集由两个文件组成，每个文件的头块记录是相同的，每个文件由“EOF”（1—3 列）终止。
- b) 第一个文件：接收点文件，包含接收点或永久标志点详细信息的若干点记录。
- c) 第二个文件：激发点文件，包含激发点详细信息的若干点记录。

I.1.2 辅助数据记录排列次序：

- a) 接收点文件：“R”记录。按照测线号、接收点号和接收点索引号排列。
- b) 激发点文件：“S”记录。按照激发点激发日期（儒略历）和时间排列。

I.1.3 辅助数据在软（光）盘上的格式。

软（光）盘技术指标包括：  
代码方式：与 MS-DOS 兼容的 ASCII 文件。  
记录长度：80 个字节，81 列为回车符，82 列为换行符。  
文件名字：文件名应与工区、观测日期和次序有关，扩展名应根据文件类型选取：  
“S”为激发点记录，如：PRJX90.S01；  
“R”为接收点记录，如：PRJX90.R01。  
一般说来，一个文件通常由若干“头块记录”开始，后跟“数据记录”。

I.2 记录说明

I.2.1 头块记录

I.2.1.1 一般介绍。

每个文件都由若干头块记录开始，后跟数据记录。头块记录中包含数据记录的有关信息以及控制数据记录的参数。

头块记录的统一格式如下：

说 明	列 号	格 式
a) 记录标识符“H”	1	A1
b) 头块记录类型	2—3	I2
c) 头块记录类型修改符	4	I1
d) 参数描述	5—32	7A4
e) 参数数据	33—80	见实例

头块记录 H0 到 H20 是所有地震勘探中都必须使用的记录，即使不填任何参数时也不能省略（H18 必须填参数）。类型为 H21 到 H25 的头块记录对于投影是必需的。

定义投影时，头块记录应用如下：

横轴墨卡托投影：H120，H231，H232，H241，H242；

通用横轴墨卡托投影：H19，H220；

球面投影：H231，H292，H241，H242；

斜墨卡托投影：H231，H232，H241，H242，H259 和 H256 或 H257 或 H258；

兰勃特圆锥投影：H210，H220，H231，H232，H241，H242。

类型为 H26 的头块记录为自由格式语句，用于表达相关信息。

I.2.1.2 头块记录说明：

- a) 5—32 列为参数说明，要求左对齐；
- b) 33—80 列输入的参数，要求左对齐；
- c) 33—34 列中只填入仪器代码或接收器代码或震源代码；
- d) 33—80 列参数域中自由格式（12A4）参数域的词法分割遵照下列原则：用逗号（,）分隔各个参数，用分号（;）终止参数串，各个参数中不得含有逗号（,）或分号（;）；
- e) 所有距离单位都为“米”。除非网格坐标单位由 H20 定义，并能通过 H201 中的转换因子，可将其转换为米。

I.2.1.3 必填头块记录。

类 型	参 数 说 明	列 号	参 数 格 式
1—4 列	5—32 列		
H00	SPS format version number (SPS 格式版本号)	33—80	12A4
H01	Description of survey area (工区说明)	33—80	12A4
H02	Date of survey (勘探日期)	33—80	12A4
H021	Post-plot date of issue (带盘发出并经检查确认的日期)	33—80	12A4
H03	Client (客户)	33—80	12A4
H04	Geophysical contractor (地球物理承包方)	33—80	12A4
H05	Positioning contractor (测量承包方)	33—80	12A4
H06	Pos.Proc.contractor (测量数据处理承包方)	33—80	12A4
H08	Coordinate location (物理点坐标位置描述)	33—80	12A4
H10	Clock time w.r.t.GMT (地方时间与格林尼治时间差)	33—80	12A4
H11	Spare (备用)	33—80	12A4
H12	Geodetic datum, - spheroid (大地基准面名等)	33—80	3A4, 3A4, F12.3, F12.7
H13	Spare (备用)	33—80	12A4
H14	Geodetic datum parameters (大地基准面参数)	33—80	3 (F8.3), 4 (F6.3)
H15	Spare (备用)	33—80	12A4
H16	Spare (备用)	33—80	12A4
H17	Vertical datum description (高程基准面描述)	33—80	12A4
H18	Projection type (投影类型)	33—80	12A4
H19	Projection zone (投影区带)	33—80	12A4
H20	Description of grid units (直角坐标单位描述)	33—56	6A4
H201	Factor to meter (直角坐标单位转换为米的比例因子)	33—46	F14.8
H210	Lat.of standard parallel (s) (标准纬线的纬度)	33—56	2 (I3, I2, F6.3, A1)
H220	Long.of central meridian (中央子午线的经度)	33—44	I3, I2, F6.3, A1
H231	Grid origin (直角坐标系中原点的经度和纬度)	33—56	2 (I3, I2, F6.3, A1)
H232	Grid coord.at origin (投影系统中原点的直角坐标值)	33—56	2 (F11.2, A1)
H241	Scale factor (比例因子)	33—44	F12.10
H242	Lat., long.scale factor (经、纬度比例因子)	33—56	2 (F11.2, A1, F6.3, A1)

H256	Lat., long.initial line (经、纬度起始线)	33—56	4 (I3, I2, F6.3, A1)
H257	Circular bearing of H256 (H256 的圆周方位角)	33—44	I3, I2, F7.4
H258	Quadrant bearing of H256 (H256 的象限方位角)	33—44	A1, 2I2, F6.3, A1
H259	Angle from skew (偏角)	33—44	I3, I2, F7.4
H26	Any other relevant information (This record can be repeated as required) [其他有关信息 (根据需要, 可重复定义本记录)]	5—80	19A4
H30	Project code and description (工区代码和描述)	33—78	3A2, 10A4
H31	Line number format (测线号格式)	33—80	12A4

I.2.1.4 质量控制头块记录。

类 型	参 数 说 明	列 号	参 数 格 式
1—4 列	5—32 列		
H990	R, S file quality control (R、S 文件的质量检查时间和负责人等)	33—60	2A4, I4, 4A4
H991	Coord.status final/prov (坐标状态及测量员等)	33—68	4A4, I4, 4A4

I.2.2 数据记录

物探测量成果记录由记录标识、线号、点号、物理点的横坐标、物理点的纵坐标、海拔高程等 6 个域组成，数据列记录的要求见表 I.1。

表 I.1 数据列记录要求

域名	域的定义	列 号	格 式	单 位	备 注
1	记录标识	1—1	A1	—	R 或 S
2	线号 (左对齐)	2—17	4A4	—	激发线或接收线的标识
3	点号 (右对齐)	18—25	2A4	—	激发点或接收点的标识
4	点索引	26—26	I1	—	范围从 1 到 9, 缺省为 1
5	点代码	27—28	A2	—	在头块中由一个表定义, 描述激发点或接收点的特征
6	物理点的横坐标 (E 向)	47—55	F9.1	m	由头块记录 H23 确定的直角坐标系中物理点的横坐标 (E), 精确至 0.1m
7	物理点的纵坐标 (N 向)	56—65	F10.1	m	由头块记录 H23 确定的直角坐标系中物理点的纵坐标 (N), 精确至 0.1m
8	地表高程	66—71	F6.1	m	物理点的海拔高程, 精确至 0.1m
注: 点代码实例: “PM” 为永久标志; “KL” 为删去或忽略该物理点, 通常指物理点空点; “G1”, …, “G9”; “H1”, …, “H9”; “R1”, …, “R9” 为接收点代码; “V1”, …, “V9”; “E1”, …, “E9”; “A1”, …, “A9”; “W1”, …, “W9”; “S1”, …, “S9” 为激发点代码。					

I.3 地震勘探测量数据 SPS 格式编码示例

I.3.1 接收点 SPS 文件

# SY/T 5171—2003

## R FILE

H00	SPS format version num.	SPS001, 08Oct1990 (SHELL EP 90 - 2935);
H01	Description of survey area	China, strn well area of tarim, xinjiang;
H02	Date of survey	start: 2001.05.14 - end: 2001.05.14;
H021	Post-plot date of issue	05/14/2001;
H03	Client	ta zhi;
H04	Geophysical contractor	BGP1;
H05	Positioning contractor	BGP1;
H06	Pos.proc.contractor	BGP1;
H08	Coordinate location	Center of source and of receiver pattern;
H10	Clock time w.r.t. GMT	- 8;
H11	Spare	
H12	Geodetic datum, - spheroid	BEIJING 54 6378245.000 298.3000000
H13	Spare	
H14	Geodetic datum parameters	15.800 - 154.400 - 82.300 0.000 0.000 0.000 0.000
H15	Spare	
H16	Spare	
H17	Vertical datum description	HUANGHAI SYSTEM, QINGDAO SHANGDONG, CHINA;
H18	Projection type	TM;
H19	Projection zone	15;
H20	Description of grid units	METERS;
H201	Factor to meter	1.00000000
H210	Lat.of standard parallel (s)	0.0000N
H220	Long.of central meridian	81.0000E
H231	Grid origin	0.000N81.0000E
H232	Grid coord. at origin	500000.00E0.00N
H241	Scale factor	1.0000000000
H242	Lat., long.scale factor	0.0000N81.0000E
H256	Lat., long.initial line	
H257	Circular bearing of H256	
H258	Quadrant bearing of H256	
H259	Angle from skew	
H26		H14 Datum transformation from Everest to WGS - 84;
H26		Local Map Coord.Grid = Easting values + 15000000m;
H30	Project code and description	STM 3-D KANTAN;
H31	Line number format	
H990	R, S file quality control	05/14/2001, 0100, MR.LIU;
H991	Coord. status final/prov	Final, 10/3/01, 1600MR.YUAN;
H26	567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890	
H26	1 2 3 4 5 6 7 8	
RSTM125		2691G1 259573.5 4582662.9 929.3
RSTM125		2701G1 259574.8 4582702.8 930.3
RSTM125		2711G1 259576.1 4582742.9 931.0
RSTM125		2721G1 259577.3 4582782.8 929.4
RSTM125		2731G1 259578.7 4582822.9 928.9
RSTM125		2741G1 259579.8 4582862.8 929.2

RSTM125	2751G1	259581.0	4582902.7	929.2
RSTM125	2761G1	259582.4	4582942.6	929.0
RSTM125	2771G1	259583.8	4582982.7	928.9
RSTM125	2781G1	259584.9	4583022.6	928.8
RSTM125	2791G1	259586.3	4583062.8	929.1
RSTM125	2801G1	259587.5	4583102.7	929.7
RSTM125	2811G1	259588.6	4583142.6	929.2
RSTM125	2821G1	259589.9	4583182.6	929.3
RSTM125	2831G1	259591.3	4583222.7	929.5
RSTM125	2841G1	259592.5	4583262.7	927.6
RSTM125	2851G1	259593.7	4583302.5	929.0
RSTM125	2861G1	259595.2	4583342.7	929.0
RSTM125	2871G1	259596.4	4583382.5	928.9
RSTM125	2881G1	259597.6	4583422.6	927.7
RSTM125	2891G1	259599.0	4583462.6	928.0
RSTM125	2901G1	259600.2	4583502.6	928.0
RSTM125	2911G1	259601.5	4583542.5	927.4
RSTM125	2921G1	259602.8	4583582.4	927.8
RSTM125	2931G1	259604.1	4583622.4	927.5
EOF				

### I.3.2 激发点 SPS 文件

#### S FILE

H00	SPS format version num.	SPS001, 08Oct1990 (SHELL EP 90 - 2935);
H01	Description of survey area	China, stm well area of tarim, xinjiang;
H02	Date of survey	start: 2001.05.14 - end: 2001.05.14;
H021	Post-plot date of issue	05/14/2001;
H03	Client	ta zhi;
H04	Geophysical contractor	BGP1;
H05	Positioning contractor	BGP1;
H06	Pos. proc. contractor	BGP1;
H08	Coordinate location	Center of source and of receiver pattern;
H10	Clock time w.r.t. GMT	- 8;
H11	Spare	
H12	Geodetic datum, - spheroid	BEIJING 54 6378245.000 298.3000000
H13	Spare	
H14	Geodetic datum parameters	15.800 - 154.400 - 82.300 0.000 0.000 0.000
H15	Spare	0.000
H16	Spare	
H17	Vertical datum description	HUANGHAI SYSTEM, QINGDAO SHANGDONG, CHI-NA;
H18	Projection type	TM;
H19	Projection zone	15;
H20	Description of grid units	METERS;
H201	Factor to meter	1.00000000
H210	Lat. of standard parallel (s)	0.0000N



# SY/T 5171—2003

H220	Long. of central meridian	81.0000E							
H231	Grid origin	0.000N81.0000E							
H232	Grid coord. at origin	500000.00E0.00N							
H241	Scale factor	1.0000000000							
H242	Lat., long.scale factor	0.0000N81.0000E							
H256	Lat., long.initial line								
H257	Circular bearing of H256								
H258	Quadrant bearing of H256								
H259	Angle from skew								
H26		H14 Datum transformation from Everest to WGS-84;							
H26		Local Map Coord.Grid = Easting values + 15000000m;							
H30	Project code and description	STM 3-D KANTAN;							
H31	Line number format								
H990	R, S file quality control	05/14/2001, 0100, MR.LIU;							
H991	Coord. status final/prov	Final, 10/3/01, 1600MR.YUAN;							
H26	567890 1234567890 1234567890	1234567890 1234567890 1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
H26	1 2 3 4 5 6 7 8								
SSTM125.5		295.51E1			259627.0	4583721.4	929.5		
SSTM126.5		295.51E1			259666.9	4583720.2	929.4		
SSTM115.5		295.51E1			259227.1	4583734.0	929.0		
SSTM127.5		295.51E1			259707.0	4583718.9	928.9		
SSTM116.5		295.51E1			259267.2	4583732.8	929.6		
SSTM128.5		295.51E1			259747.0	4583717.6	928.4		
SSTM117.5		295.51E1			259307.4	4583731.5	930.3		
SSTM129.5		295.51E1			259787.0	4583716.4	928.1		
SSTM118.5		295.51E1			259347.2	4583730.3	929.5		
SSTM130.5		295.51E1			259826.9	4583715.0	928.4		
SSTM119.5		295.51E1			259387.2	4583729.0	927.3		
SSTM131.5		295.51E1			259866.9	4583713.8	929.0		
SSTM120.5		295.51E1			259427.3	4583727.7	929.2		
SSTM132.5		295.51E1			259907.0	4583712.7	929.0		
SSTM121.5		295.51E1			259467.0	4583726.6	929.2		
SSTM122.5		295.51E1			259507.1	4583725.2	929.5		
SSTM114.5		295.51E1			259187.2	4583735.4	929.5		
SSTM116.5		308.51E1			259283.7	4584252.8	928.9		
SSTM125.5		308.51E1			259643.6	4584241.2	927.8		
EOF									

附录 J  
(资料性附录)  
物探测量成果整理格式

J.1 技术说明格式

技术说明

队 号		工区		施工年度	年 月
仪器型号					
执行技术标准			成图比例尺		
坐标系统			高程系统		
控制点总数	个		导线总数	条 km	
物探测线总数	条	导线测量		km	
	km	实时差分测量		km	
导线质量	点位中误差	± m	物理点 测量质量	$m_x = \pm$ m	$m_y = \pm$ m
	高程中误差	± m		$m_h = \pm$ m	

注 1: 导线点位中误差  $m_s = \frac{1}{2} \sqrt{\frac{[f_s^2]}{n}}$   
 $n$  为导线闭合差个数。

注 2: 导线高程中误差  $m_h = \frac{1}{2} \sqrt{\frac{[f_h^2]}{n}}$   
 $n$  为导线闭合差个数。

注 3: 物理点测量纵坐标中误差  $m_x = \sqrt{\frac{\sum_{i=1}^n (\Delta x_i)^2}{2n}}$   
 $\Delta x_i = x_i - x'_i$   
 $x_i$  为复测物理点纵坐标,  $x'_i$  为实测物理点纵坐标,  $n$  为物理点总数。

注 4: 物理点测量横坐标中误差  $m_y = \sqrt{\frac{\sum_{i=1}^n (\Delta y_i)^2}{2n}}$   
 $\Delta y_i = y_i - y'_i$   
 $y_i$  为复测物理点横坐标,  $y'_i$  为实测物理点横坐标,  $n$  为物理点总数。

注 5: 物理点测量高程中误差  $m_h = \sqrt{\frac{\sum_{i=1}^n (\Delta h_i)^2}{2n}}$   
 $\Delta h_i = h_i - h'_i$   
 $h_i$  为复测物理点高程,  $h'_i$  为实测物理点高程,  $n$  为物理点总数。

J.2 二维 (三维) 测线端点实测坐标与设计坐标较差统计表格式

二维（三维）测线端点实测坐标与设计坐标较差统计表

测线号	点号	点代码	实测坐标		设计坐标		较 差			备 注
			<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	$\Delta x$	$\Delta y$	$\Delta s$	

制表:

注: 点代码示例:  
R—首尾接收点;  
S—首尾激发点;  
O—首尾一次覆盖点;  
F—首尾满覆盖点。

审核:

J.3 二维测线交叉联测检核质量统计表格式

二维测线交叉联测检核质量统计表

后施工 测线号	前施工 测线号	后施工测线 物理点成果				前施工测线 物理点成果				物理点点 位 较 差		备 注
		物理 点号	<i>x</i>	<i>y</i>	<i>h</i>	物理 点号	<i>x</i>	<i>y</i>	<i>h</i>	$\Delta s$	$\Delta h$	

制表:

注:  $\Delta s = \sqrt{\Delta x^2 + \Delta y^2}$

审核:





**The People's Republic of China**  
**Standard of Petroleum and Natural Gas Industry**

**SY/T 5171—2003**

Replace SY/T 5171—1999, SY/T 5927—2000, SY/T 6291—1997,  
SY/T 5775—2002, SY/T 5828—1999, SY/T 5931—2000

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**Specification for surveying in  
petroleum geophysical exploration**

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## Foreword

This standard is derived, compiled and revised based on the following six existing surveying standards :

——SY/T 5171—1999 *Specifications for surveying in petroleum geophysical exploration* ;

——SY/T 5927—2000 *Specifications for GPS surveying in petroleum geophysical exploration* ;

——SY/T 6291—1997 *Specifications for GPS kinematic surveying in petroleum geophysical exploration* ;

——SY/T 5775—2002 *Specifications for surveying of seismic exploration in mountain areas* ;

——SY/T 5828—1999 *Detailed procedures of quality check and acceptance for survey results in petroleum geophysical exploration* ;

——SY/T 5931—2000 *Specifications for use and maintenance of survey instruments* .

This standard shall replace the above six standards at the beginning on the date of issue.

Compared with the above six standards, this standard emphasize these two key points:

——This standard provide detailed depictions of GPS surveying techniques, and they simplify

conventional methods.

——This standard describe in detail the surveying methods in petroleum geophysical prospecting, and they simplify information about use and maintenance of surveying instruments.

This standard refers to overseas oil companies' specifications to ensure that it complies with international standards and meets international surveying requirements.

Annexes A and F are normative. Annexes B, C, D, E, G, H, I and J are informative.

This standard was proposed by The Committee of Petroleum Geophysical Standardization , it is under the jurisdiction of The Committee of Petroleum Geophysical Standardization.

This standard was drafted by Surveying & Mapping Center, BGP, CNPC.

The main drafters of this standard are Shaobin Sun, Changhua Yi, Jianmin Song, Shuhai Wang, Peishu Wang and Shaoyu Wu.

This standard is published in both Chinese and English. In the event of any discrepancy between the texts, the Chinese version shall prevail.

# Specification for surveying in petroleum geophysical exploration

## 1 Scope

This standard stipulates the technical requirements and methods to be followed during petroleum geophysical prospecting surveys.

This standard applies to the land petroleum geophysical prospecting surveying.

## 2 Normative reference

The following documents contain provisions which, through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments to, or revisions of, any of these publications (exclude errata) do not apply. However, parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. For undated references, the latest edition of the document referred to applies.

GB/T 18314—2001 *Global positioning system (GPS) survey specification*

## 3 Terms and definitions

The following terms and definitions are applicable to this standard.

### 3.1

#### surveys in petroleum geophysical exploration

A general term for all surveys conducted to facilitate petroleum geophysical prospecting.

### 3.2

#### conventional survey

A general term for surveys conducted with instruments—including theodolite, EDM and total station—to distinguish the surveys from satellite positioning surveys.

### 3.3

#### geophysical point

A general term for receiver points and source points

in seismic exploration or for various observation points in non-seismic prospecting.

### 3.4

#### observation session

The working period of a GPS receiver on a station from receipt of the first satellite signal to the survey's conclusion.

### 3.5

#### simultaneous observation

Observation of the same satellite constellation by two or more receivers at the same time.

### 3.6

#### simultaneous loops

A close loop composed of baseline vectors made available from the simultaneous observations acquired by three or more receivers.

### 3.7

#### unsimultaneous loops

A close loop composed of baseline vectors made available from an unsimultaneous observation.

### 3.8

#### antenna height

The height between the phase center of the receiver antenna and the marker horizon of the center of the station during the survey.

### 3.9

#### baseline solution

Computing the coordinate difference between two simultaneous survey stations.

### 3.10

#### coordinates transformation parameters

A general term for a number of parameters necessary for the expression of the mathematic relation involved in the coordinate system conversion.

### 3.11

#### reference station

During a specified period of observation, one or more receivers are fixed on one or several survey



stations to keep track of the satellites, while other receivers engage in mobile operation around these survey stations. These fixed survey stations are referred to as reference stations.

### 3.12

#### roving station

Survey stations set up by receivers engaged in mobile operation around reference stations.

### 3.13

#### real time differential survey

A survey method in which data collected by the GPS receiver on the reference station is transmitted in real-time via communication links to GPS receivers on roving stations so that the relative position of the two stations can be calculated in real-time. This method includes RTK and RTD.

### 3.14

#### static positioning

GPS survey to determine the relative position between survey stations by performing simultaneous observation for a number of sessions on multiple survey stations.

### 3.15

#### fast static positioning

A static GPS survey performed on the principle of fast ambiguity resolution approaching.

### 3.16

#### electronic handbook

A microcomputer capable of both communicating with the survey instrument and recording data.

## 4 General

**4.1** The task of the petroleum geophysical prospecting survey, pursuant to the design of the geophysical prospecting, is to stake out geophysical points of prospecting lines using a specific survey method, and to provide compliant survey results and drawings for the field operation, data processing and interpretation.

**4.2** All national control points, or those deployed in accordance with GB/T 18314—2001 or Chapter 6 in this standard, can serve as references for the

calculation of the petroleum geophysical prospecting surveying. The control points being used shall be verified.

**4.3** The Beijing Coordinate System (1954) and the Huanghai Height System (1956) are to be used when calculating the final coordinate and height for the geophysical points. The coordinate system required by the prospecting design may also be adopted in the final result.

**4.4** When the scale of mapping is less than 1:10 000, plane coordinates of the geophysical points shall be calculated by using the Six Degree Zone Gauss Projection (TM Projection, the scale of Central Meridian Projection Rate is 1); when the scale of mapping is equal to or larger than 1:10 000, the plane coordinates of the geophysical points shall be calculated by using the Three Degree Zone Gauss Projection. The projection and zoning methods required by the prospecting design may also be adopted when calculating the plane coordinates of the geophysical points.

**4.5** Traverse, polar coordinates staking-out, GPS real-time differential and other surveying methods that provide the same accuracy can be used when staking out geophysical points. The GPS post-processing differential survey can be used in both the seismic exploration points offset survey and non-seismic prospecting survey.

**4.6** On the prospecting result map, the requirements of MSE (Mean Square Error) for geophysical points relative to the nearest control points in the work site are as follows:

- a) Not greater than 0.4 millimeter (mm) for the two-dimensional (2-D) seismic, gravity, or electric-magnetic prospecting;
- b) Not greater than 0.2 millimeter (mm) for the three-dimensional (3-D) seismic prospecting;
- c) Not greater than 1 millimeter (mm) for the geo-chemical prospecting.

The tolerance for geophysical points elevation error relative to the nearest control point in the worksite is described in Table 1.

Table 1: Geophysical point height MSE

Item		Mapping scale			
		1:25 000	1:50 000	1:100 000	1:200 000
		Mean square error, m			
Seismic		1.0	1.5	2.0	
Gravity survey	Flat, Hill	0.2		0.4	0.8
	Mountain	0.4		0.7	1.2
Magnetic exploration and Geo-chemical exploration		30.0			
Electric method	Telluric electromagnetic survey	5.0			
	Continuous electromagnetic profiling survey				
	TEM survey	20.0			

**4.7** The various tolerances in this specification shall be twice MSEs.

**4.8** It shall be an east-west line when the line grid azimuth is within  $45^\circ \pm 180^\circ \sim 135^\circ \pm 180^\circ$  (including  $45^\circ \pm 180^\circ$  and  $135^\circ \pm 180^\circ$ ), and a north-south line when the azimuth is within  $135^\circ \pm 180^\circ \sim 225^\circ \pm 180^\circ$ .

**4.9** The numbering of geophysical points shall be the same as the geophysical prospecting design; the coordinates of geophysical points that can not be surveyed shall be made available through interpolation and shall be marked in the final result.

**4.10** The coordinate and height of the geophysical points shall be measured in the field, or interpolated when the accuracy of the geophysical prospecting can be met in flat surface or equal gradient regions of small fluctuation, for instance the beach area.

**4.11** The intersection point shall be checked when 2-D lines intersect:

- The discrepancy in tie-survey point's position shall not exceed 0.2mm when the mapping scale is greater than or equal to 1:25 000. Otherwise, shall not exceed 0.1mm.
- The height difference between tie-survey geophysical points (or intersection points in office calculations) shall not exceed 2 m in a flat re-

gion and shall not exceed 3 m in mountains and/or hilly areas. The points will be checked if they exceed the tolerance.

**4.12** The following shall be meet the technical design and contract requirements:

- The allowable offset of receiver and source point;
- The receiver interval, source interval and the allowable range of change;
- Range of coordinates difference between pre-plotted and post-plotted on full coverage endpoints, and line endpoints; and
- Mapping scale.

**4.13** The Survey Line Qualified Notice, survey line sketch and survey result shall in time be provided after the survey, computing, checking and confirmation. Refer to Annex B for the format of the Survey Line Qualified Notice.

**4.14** Requirements for laying out non-seismic exploration survey lines:

- Electric survey line shall be generally laid out in straight line. Bent line is acceptable in special circumstances, but the space variation region must not exceed 20 percent;
- Survey lines shall be deployed with the regular network in gravimeter survey, magnetic and geo-chemical exploration; the least amount of

points per square kilometer shall be determined in term of requirements in difficult areas;

- c) Non-seismic survey points can be staked out by fast static or other survey methods that meet prospecting requirements. Specification shall follow prospecting requirements.

4.15 Data processing software shall be verified and approved by the technical authority before application.

5 Preparation

5.1 Data collection:

- a) Topographical maps, geodetic control points, geodetic transformation parameters, geoid and other relative data;
- b) Administrative region maps, traffic maps, meteorological data, and map of ground or underground facilities; and
- c) Existing survey line data.

5.2 Scouting:

- a) The location, stability and reliability check of the worksite' control points;
- b) The worksite topography, feature, administration, industrial and agricultural location, human culture, traffic and weather, etc.;
- c) Review the location and orientation of the survey line in the field with geophysical prospecting and geological staff, compiling the scouting report and working out the operation plan.

5.3 Compiling survey operation design. Refer to Annex C for details.

5.4 Instrument test and accreditation: Instrument test may be performed by the user, while the inspection must be conducted by the official inspection institution. Usually, the inspection period shall not be longer than one year.

6 Control survey

GPS network control is the preferred for control survey, but traverse control method is acceptable.

6.1 GPS network control

6.1.1 General technical requirements.

6.1.1.1 Petroleum geophysical prospecting GPS

network is classified into Level I, II and III to accuracy, as shown in Table 2.

Table 2: GPS network classification

Order	I	II	III
Max. side length km	≤400	≤200	≤30
Average side length km	50≤S≤150	10≤S<50	3≤S<10
Relative accuracy × 10 <sup>-6</sup>	≤3	≤5	≤10

6.1.1.2 The observation session and other parameters shall be determined in accordance with the requirements in Table 3 and 4, which outline baseline length and accuracy requirements.

Table 3: GPS observation condition requirements

Method	PDOP	Number of SV	Sample rate s	SV elevation mask (°)
Static	≤8	≥4	1~60	≥12
Fast static	≤8	≥4	1~15	≥10

Table 4: GPS observation session requirements

Method	Baseline length km	Single frequency receiver	Dual frequency receiver
		Simultaneous observation time min	Simultaneous observation time min
Static	S<20	≥45	≥30
	20≤S<80	≥90	≥60
	80≤S<200	—	≥120
	S≥200	—	≥150
Fast static	S≤20	≥10	≥5

6.1.1.3 Baseline accuracy shall be expressed by Formula 1, and it shall comply with Table 5.

$$\sigma = \sqrt{a^2 + (bd \times 10^{-6})^2}$$
 (1)

Where:

σ—standard deviation (baseline vector MSE) in mm;

$a$ —fixed error in mm;  
 $b$ —ratio error coefficient;  
 $d$ —adjacent point distance in km.

**Table 5: GPS baseline accuracy specification of petroleum geophysical prospecting**

Order	I	II	III
Fixed error $a$ , mm	$\leq 5$	$\leq 10$	$\leq 10$
Ratio error coefficient $b$	$\leq 1$	$\leq 2$	$\leq 10$

**6.1.1.4** During the evaluation of the accuracy of the ellipsoid height difference of the GPS survey, fixed error “ $a$ ” and ratio error coefficient “ $b$ ” may be released twice in the indexes given in Table 5.

**6.1.1.5** In baseline processing, fixed double-difference solutions shall be made available for a baseline shorter than 15km; the optimized solution of double-difference fixed-integer solution and double-difference float solution shall be adopted when the baseline length is equal to or greater than 15 km.

**6.1.1.6** Coordinate parameters shall be in accordance with existing data, and shall be obtained by the following priorities:

- Parameters that were authenticated by relative departments and were approved for use in the working area;
- Parameters calculated from GPS network;
- Parameters determined by SPP (the observation duration thereof shall not be less than two hours).

**6.1.1.7** Difference between known and computation coordinates in the known points of the network after coordinate transformation shall not exceed:  $\Delta X \leq 0.5\text{m}$ ,  $\Delta Y \leq 0.5\text{m}$ ,  $\Delta H \leq 1.0\text{m}$ ; Difference between coordinates from various computation routes in the network shall also comply with the same requirements.

**6.1.1.8** After the coordinate transformation, the ellipsoid height shall be adjusted to the geoid height by using the following formula:

$$h = H - \xi \quad (2)$$

Where:

$H$ —ellipsoid height in m;

$h$ —geoid height in m;

$\xi$ —height anomaly value in m.

The height anomaly value shall dovetail with the existing data of the survey area, and shall be made available in accordance with the following priorities:

—Height anomaly model approved for use in the worksite by the related department upon authentication;

—Digital height anomaly map or measurement from the height anomaly map with scale not less than 1 : 2 500 000 (readings down to 0.1m);

—Height fitting.

**6.1.1.9** Generally when calculating the geoid height of a GPS point through the height fitting method, the known height control points shall not be less than three. If the known height control points are less than three or not uniformly distributed, tie-survey with height control points nearby shall be performed.

**6.1.2** GPS network design.

**6.1.2.1** The number of known plane control points shall not be less than two in the petroleum geophysical prospecting GPS network. The benchmark point, if available nearby, shall be included in the GPS network for height control.

**6.1.2.2** The design shall be carried in accordance with the control scope and purpose, the known points shall be distributed as uniformly as possible. If the benchmark has to be tied-in, the leveling survey route shall be provided on the map.

**6.1.2.3** Methods of side connection, net connection and side-point connection may be introduced in petroleum geophysical prospecting GPS network deployment, and the network shall be formed into closed figure or connecting figure. Point connection may be introduced in hard-to-access regions, or when the accuracy requirement can be met.

**6.1.3** Site selection and monument embedment.

**6.1.3.1** Requirements for point location in the site selection:

- a) Selection of the point location shall comply with the requirements of the technical design, and must favor the extension and tie-survey by other survey methods;
- b) The point location shall be in stable ground foundation, can be used for a long time, be easy access, and be easily used with equipment;
- c) Open sky view, no obstruction 10° above the line of sight;
- d) Keep away from high-power wireless radiation sources (such as TV stations and microwave stations) and high-voltage electricity transmission lines;
- e) No objects present to interfere signal reception. An anti-multipath antenna shall be used off-shore or on a large body of water;
- f) Make the most use of existing control points and monuments in compliance with the above requirements.

**6.1.3.2** Steel tube, cement monument or wooden stake may be used for GPS markers. The central marker shall be made stable for all classes GPS control points. Its radius shall not exceed 2mm.

**6.1.3.3** After the site selection and monument embedment of class I GPS network, station description and network sketch shall be submitted. Refer to Annex D for station descriptions.

#### **6.1.4** Field observation.

##### **6.1.4.1** Observation plan:

- a) The age of the ephemeris used for the GPS visibility forecast shall not exceed 30 days. The forecast table shall include the number of visible satellites, satellite elevation angle and azimuth, optimum observation satellite constellation, optimum observing session and DOP value, etc;
- b) The observation schedule shall cover the observation time, number and name (s) of survey station (s), observation parameters and receivers' serial numbers.

##### **6.1.4.2** Observation:

- a) Operations shall comply with the schedule;
- b) The centering error for antenna setup shall be

$\leq 5$  mm;

- c) While setting up antenna with direction mark, the antenna's shall be pointed to true north within a 10° error;
- d) The GPS antenna's height shall be measured before and after each observation session, and the height difference shall not exceed 3 mm;
- e) The following operations are prohibited during an observation session: shutting down and restart the receiver; performing self-testing (with the exception of spotting fault); changing satellite's elevation mask, data sample rate and antenna position; closing or deleting files;
- f) Use of the two-way radios and/or mobile phones is prohibited in the vicinity of the working receiver. In event of a thunderstorm, turn off all equipment, end the observation and dismount the antenna;
- g) Fill in the logbook carefully during the observation. Refer to Annex E for the logbook format;
- h) After completion the observation, download and backup the data in time;
- i) Perform the instrument test and maintenance regularly to ensure the instrument is functioning properly. Refer to Annex F for details.

#### **6.1.5** Data processing.

##### **6.1.5.1** GPS baseline processing:

- a) The satellite broadcast or precise ephemeris may be used as the initial data for the baseline processing;
- b) In the course of the baseline processing, the technical design requirements shall be followed while checking the quality of the baseline observation. Where the elimination proportion of the effective data shall be  $\leq 30$  percent, the baseline solution accuracy shall comply with 6.1.1.1 and 6.1.1.3;
- c) The length difference ( $ds$ ) between the repeated baselines shall meet the requirements of the following expression:

$$ds \leq 2\sqrt{2}\sigma \quad (3)$$

##### **6.1.5.2** GPS network loop misclosures:

a) The simultaneous loop misclosure shall meet:

$$\left. \begin{aligned} W_x &\leq \frac{\sqrt{n}}{5} \sigma \\ W_y &\leq \frac{\sqrt{n}}{5} \sigma \\ W_z &\leq \frac{\sqrt{n}}{5} \sigma \\ W &= \sqrt{W_x^2 + W_y^2 + W_z^2} \leq \frac{\sqrt{3n}}{5} \sigma \end{aligned} \right\} \quad (4)$$

b) The unsimultaneous loop misclosure shall meet:

$$\left. \begin{aligned} W_x &\leq 3\sqrt{n}\sigma \\ W_y &\leq 3\sqrt{n}\sigma \\ W_z &\leq 3\sqrt{n}\sigma \\ W &\leq 3\sqrt{3n}\sigma \end{aligned} \right\} \quad (5)$$

Where,  $W_x$ ,  $W_y$  and  $W_z$  are misclosures of  $x$ ,  $y$  and  $z$  vectors respectively,  $W$  is the loop misclosure and  $n$  is the number of sides composing the loop.

#### 6.1.5.3 GPS network adjustment:

- a) After all checks passed the requirements, the minimally constrained adjustment shall be performed. During which, a closed figure shall constitute all baselines, while the 3-D baseline vectors, their variance and covariance matrixes shall be used as the observation information and WGS-84 coordinates of a point as the initial data.
- b) The fully constrained 3-D or 2-D adjustment shall be performed on the basis of the effective observations determined by the minimally constrained adjustment. The known coordinates of a control point, distance or azimuth may be used as the force constrained fixed values or weighted observation.
- c) In the minimally constrained adjustment, the absolute corrections of baseline vectors ( $V_{\Delta Y}$ ,  $V_{\Delta X}$  and  $V_{\Delta Z}$ ) shall meet requirements of the following expressions:

$$\left. \begin{aligned} V_{\Delta X} &\leq 3\sigma \\ V_{\Delta Y} &\leq 3\sigma \\ V_{\Delta Z} &\leq 3\sigma \end{aligned} \right\} \quad (6)$$

- d) The difference between baseline vector corrections in the fully constrained adjustment and the minimally constrained adjustment corrections after removing gross errors for the same baseline ( $dV_{\Delta X}$ ,  $dV_{\Delta Y}$  and  $dV_{\Delta Z}$ ) shall meet the requirements of the following expressions:

$$\left. \begin{aligned} dV_{\Delta X} &\leq 2\sigma \\ dV_{\Delta Y} &\leq 2\sigma \\ dV_{\Delta Z} &\leq 2\sigma \end{aligned} \right\} \quad (7)$$

#### 6.1.6 Resurvey and remedial survey:

- a) The resurvey and remedial survey shall be conducted in case the survey plan has not been followed, if observations have been missed and/or omitted in the field, or the processed observation data do not comply with 6.1.5.1, 6.1.5.2 and 6.1.5.3;
- b) The analysis for the resurvey and remedial survey shall be described in the data processing report.

6.1.7 Compile final report for the GPS control survey. Please refer to Annex G for the format of the report.

### 6.2 Traverse survey control

6.2.1 Arrange the traverse survey control shall be arranged with the connecting traverse. Refer to Table 6 for various tolerances.

6.2.2 Technical requirements for traversing.

#### 6.2.2.1 Side length survey:

- a) The traverse side length shall be measured with EDM instrument. Add constant, multiply constant and meteorological correction and other corrections stipulated in the operation manual shall be applied during field observation;
- b) To conduct single-target survey two times with readings down to 0.001 m, take the arithmetic mean;
- c) The maximum traverse side length shall not exceed 2 km.

#### 6.2.2.2 Angular survey:

- a) The horizontal and vertical angles shall be measured by theodolite with precision better than 2" or total station with angle measurement MSE

better than 3" of for two observation sets;

Table 6: Technical requirements for traverse control survey

Item		Tolerance	Comment
Traverse tolerance	Total length, km	40	Halve length in 3-D prospecting
	Azimuth misclosure, (")	$40 \sqrt{N}$	N is station number
	Relative accuracy	1/5000	It shall be computed with 10km when length is less than 10km
	Height misclosure, m	$0.20 \sqrt{S}$	S is total length in km
Observation tolerance	Difference of twice collimation error, (")	45	
	Difference of vertical index error, (")	45	
	Difference of one set horizontal angle, (")	30	
	Difference of distance measurement, m	0.03	
	Reciprocal height difference error, m	0.3L	It shall be computed with 0.3km when the length is shorter than 0.3km, L is length in km

b) The tolerances for observing the horizontal and vertical angles are given in Table 6.

6.2.2.3 The instrument and target height measurement readings shall be down to 0.001m.

6.2.2.4 National control points, GPS static or fast static positioning points may be used as the starting and closing points of the traverse.

7 Geophysical points deployment

7.1 Geophysical points coordinates and height determination methods:

- a) Traversing;
- b) Polar coordinates stake out;
- c) Combination survey of traversing and polar coordinates staking out;
- d) Real-time differential survey;
- e) Combination survey of polar coordinates staking out and real-time differential survey;
- f) Static survey;
- g) Other survey methods that meet the accuracy requirements of geophysical prospecting.

7.2 Traversing.

7.2.1 Types of traverse deployment:

- a) Connecting traverses;
- b) Closed traverses;
- c) Open traverses.

7.2.2 Refer to Table 7, 8 and 9 for various traverse tolerances. The traverse length can be extended moderately when in special terrain such as mountain areas, and the length can be extended by 50 percent when seismic exploration mapping scale is greater than or equal to 1:25 000; in case that a traverse length is shorter than 10km, its tolerance shall be calculated based on that length.

7.2.3 Technical requirements for the traverse observation.

7.2.3.1 Side length survey:

- a) Refer to 6.2.2.1 a) for traverse side length survey methods;
- b) Side length shall be measured by single target twice with the readings down to 0.01m, the inter-difference between the two readings shall

not exceed 0.05m, taking the arithmetic mean;

**Table 7: Primary technical specifications for traversing**

Mapping scale	Traverse length km	Relative precision	Azimuth misclosure (")	Elevation misclosure m
1:10 000	15	1/3 000	$60 \sqrt{N}$	$0.40 \sqrt{S}$
1: 25 000	20			
1:50 000	30	1/2 500		
1:100 000	40			
Note: $N$ represents the number of survey stations and $S$ represents traverse length in km.				

**Table 8: Horizontal angle and vertical angle observation tolerance**

Instrument grade	2C error difference	Inter-difference of index error
J2	$\pm 45''$	$\pm 45''$
J6	$\pm 60''$	$\pm 60''$

**Table 9: Open traverses**

Mapping scale	Open traverse length, km
1:10 000	1
1:25 000	
1:50 000	3
1:100 000	

- c) The maximum traverse side length shall not exceed 2 km, which can be extended to 4 km in mountainous and similar other regions.

#### 7.2.3.2 Angular survey:

- a) The horizontal and vertical angles shall be measured using a theodolite or total station with less than  $6''$  MSE of angle measurement in one observation set;
- b) Refer to Table 8 for horizontal and vertical angle observation tolerance of a station.

#### 7.2.3.3 Height survey:

- a) The traverse height shall be observed using the foresight and back-sight target. The tolerance for the height difference discrepancy of the foresight and back-sight target shall be calculated by  $0.4L$ . In case the traverse side length is

less than 0.5km, the tolerance shall be calculated by 0.5km.  $L$  is the side length in km, and calculation results in m.

- b) Readings of instrument and target height shall be measured down to 0.01m.

#### 7.2.3.4 Field correction.

It is strongly required the following corrections be made in field:

- a) Correction of the distance projected to the geoid;
- b) Correction of the distance reduction to the Gauss plane;
- c) Correction of the earth curvature and atmosphere refraction error.

#### 7.2.3.5 National control points, traverse control points, GPS static or fast static positioning points



or checked RTK points can be used as the starting and closing points of the traverse.

**7.2.3.6** The starting and closing azimuths of the traverse may be determined by the two-point inverse computation or astronomical azimuth survey.

**7.2.3.6.1** The following methods may be introduced for the astronomical azimuth survey:

- a) Method of Sun altitude;
- b) Method of Polaris hour angle;
- c) Method of Sun hour angle.

**7.2.3.6.2** Requirements for the astronomical azimuth survey:

- a) No less than three observation sets shall be performed in the azimuth observation, and each set shall be observed within 10 minutes;
- b) On the observation day, make sure your watch time agrees with the local time, and the air temperature shall be measured down to one degree;
- c) The Sun's elevation shall not be lower than  $8^\circ$ .  
It would be better not to survey the sun azimuth between 10:00 to 14:00 (local time) when adopting the Sun altitude method;
- d) The difference between grid azimuths calculated in each observation set shall not exceed  $1'$  and the final result shall be their arithmetic mean.

**7.3** Geophysical point polar coordinates stake out.

**7.3.1** The coordinates of geophysical points and height may be measured with half observation set using the single-target, and the measurement can be conducted with traversing, with  $30''$  horizontal angle return-to-zero tolerance.

**7.3.2** Refer to 7.2.3.4 for field correction.

**7.3.3** Resurvey and remedial survey: In the event that survey stations and geophysical point data fail to comply with the requirements, a resurvey or remedial survey must be conducted. Such measures shall be taken whenever problems appear during the data-processing period.

**7.3.4** Repeated survey.

**7.3.4.1** In one of the following cases, the check shall be performed with the repeated survey on

more than two geophysical points or on one single control point twice before the operation starts:

- a) Station change;
- b) Back-sight direction change;
- c) Re-centering and leveling;
- d) Instrument restart.

**7.3.4.2** A repeated survey ratio shall be conducted on at least 1 percent of the geophysical points for each swath survey line.

**7.3.4.3** Discrepancy tolerance for the repeated survey:  $\Delta x \leq 0.6\text{m}$ ,  $\Delta y \leq 0.6\text{m}$ ,  $\Delta h \leq 1.0\text{m}$ .

**7.4** A manual or electronic record may be used, depending on the operation method and survey instrument.

**7.4.1** The manual record shall be an objective, and in a readable manner. Various annotations and all calculations shall be completed before moving to the next station.

**7.4.2** Protective measures shall be taken for raw data in the electronic record.

**7.5** Data processing for traversing and polar coordinates stake out.

**7.5.1** The traverse data shall be calculated using the simple adjustment method. Angle misclosure shall be assigned based on the number of survey stations. Misclosures of coordinates and heights shall be done proportionally, according to the side length.

**7.5.2** The three corrections outlined in 7.2.3.4 shall be added to the calculated result if they were neglected in the field.

**7.5.3** Raw and initial data for calculations will not be used until they have been checked.

**7.5.4** Raw data recorded in magnetic cards, electronic handbook or instrument memory shall be edited in the following ways:

- a) The incorrect point number and station relationship can be edited, under no circumstances shall raw observations be edited, including the angle and side length. The instrument and target heights can be edited and revised by referring to the field logbook;
- b) Delete the incorrect, redundant data and the

data having the duplicate name in one survey station;

- c) In the event there are common segments, the common parts of the traverses may be used to combine a complete traverse with the independent segments.

**7.5.5** The memorandum shall be provided during data processing.

**7.5.6** The placing of the decimal shall comply with the following requirements while processing data:

- a) The distance, coordinate and height shall be rounded down to 0.01m;
- b) The horizontal angle, vertical angle and azimuth shall be rounded down to 1".

**7.6** Real-time differential survey stake out.

**7.6.1** Reference station.

**7.6.1.1** Reference station permitted on a control point, or other reference stations, must be checked. Refer to 7.6.1.3.

**7.6.1.2** When real-time differential and polar coordinates method are both introduced in the geophysical points stake out, geophysical points with fixed marks and surveyed through the RTK survey may be used as the traverse control points, and the traverse points shall not be used as reference stations.

**7.6.1.3** Reference station extension:

- a) The reference station shall not be developed more than three times sequentially.
- b) The accumulated baseline length between reference stations and control points shall not exceed 50km.

c) Check each extended reference station:

——Checking object: A reference station or the geophysical points with fixed marks surveyed by the reference station;

——Checking method: Static, fast static or real-time differential surveys;

——Checking tolerance:  $\Delta x \leq 0.2\text{m}$ ,  $\Delta y \leq 0.2\text{m}$ ,  $\Delta h \leq 0.4\text{m}$ .

**7.6.2** Rover station:

- a) The distance from the rover station to the refer-

ence station shall be within the range of 20 km;

- b) The rover point information shall not be recorded unless the antenna remains in a fixed position.

**7.6.3** Check.

**7.6.3.1** In one of the following circumstances, a check shall be performed with the repeated survey on more than two geophysical points or on one single control point twice before the operation starts:

- a) Before daily operation;
- b) When reference station changes;
- c) After the update of data or parameters in the receiver or electronic handbook.

**7.6.3.2** Repeated survey ratio shall be conducted on at least 1 percent of the geophysical points for each swath survey line.

**7.6.3.3** Static or fast static survey shall be performed to check the end points of each 2-D survey line;

**7.6.3.4** Tolerance of repeated survey:

- a)  $\Delta x \leq 0.6\text{m}$ ,  $\Delta y \leq 0.6\text{m}$ ,  $\Delta h \leq 1.0\text{m}$  (Real-time phase differential survey);
- b)  $\Delta x \leq 1.0\text{m}$ ,  $\Delta y \leq 1.0\text{m}$ ,  $\Delta h \leq 1.5\text{m}$  (Real-time pseudo-range differential survey);
- c)  $\Delta x \leq 1.5\text{m}$ ,  $\Delta y \leq 1.5\text{m}$ ,  $\Delta h \leq 1.5\text{m}$  (Post-processing differential survey).

**7.6.4** Data processing for real-time differential survey.

**7.6.4.1** Download and backup raw data to avoid losses.

**7.6.4.2** Data processing shall not be postponed to the following day and the remedial survey and resurvey shall be performed without delay when missing points or points whose position errors exceed the tolerance are found. Such situations must be carefully documented.

**7.6.4.3** When a rover station's GPS height is adjusted to geoid height, its height anomaly may be obtained using one of the following approaches, with priorities listed below:

- a) Based on the height anomaly model approved by the authentic department, and allowed to use in the working area;

- b) Extracted from digital height anomaly maps, or measured from height anomaly maps with scale of 1:2 500 000 or greater, with readings down to 0.1m;
- c) By using interpolation or fitting;
- d) Corrected roving station's height using the reference station's height anomaly when height anomaly difference between reference station and rover station does not exceed 0.5m.

## 8 Data sorting

All useful data, reports, documents, maps, etc. shall be carefully sorted out and/or processed and then saved in a computer for quick reference. Hard copies can be made. Copies of such information must be presented after each operation.

### 8.1 Hard-copy data.

#### 8.1.1 General content:

- a) Operation design;
- b) Operation summary (refer to Annex H);
- c) GPS control survey report;
- d) Geophysical point survey result;
- e) Geophysical prospecting survey quality statistics.

#### 8.1.2 Detailed content and binding sequence.

##### 8.1.2.1 2-D line geophysical points survey result:

- Cover;
- Auxiliary cover;
- Table of contents;
- Technical specifications;
- Initial data;
- First and last receiver points, one fold points, source points and full fold points lists;
- Geophysical points lists;
- Table of skipped receiver points;
- Survey line position diagram.

##### 8.1.2.2 3-D line geophysical points survey result:

- Cover;
- Auxiliary cover;
- Table of contents;
- Technical specification;

- Initial data;
- 3-D survey area, and border inflection point coordinates of the operation boundary;
- 3-D pre-migration full fold area, and border inflection point coordinates;
- 3-D one-fold area, and border inflection point coordinates;
- Geophysical points result;
- Table of skipped receiver points;
- Retrievable source points result;
- Survey line position diagram.

##### 8.1.2.3 Geophysical prospecting survey quality statistics:

- Cover;
- Table of contents;
- Client checking and acceptance memo;
- Contractor checking and acceptance memo;
- Technical specifications;
- Seismic line quality statistics;
- Traverse survey quality statistics;
- Comparison of coordinate statistics of pre-plotted and post-plotted 2-D and 3-D lines starting and ending points;
- 2-D line intersection;
- 2-D line intersection quality control statistics;
- Geophysical points quality control statistics;
- Survey line position diagram.

### 8.2 Soft-copy data:

- a) Raw record of geophysical points and GPS survey;
- b) Geophysical points survey result (result of two zones shall be provided when lines cross two projection zones), refer to Annex I for storage format;
- c) Seismic line quality statistics, refer to Annex J for relative format:
  - Seismic line quality statistics;
  - Traverse survey quality statistics;
  - Control points result;
  - Comparison of coordinate statistics of pre-plotted and post-plotted 2-D & 3-D lines starting and ending points;
  - 2-D line intersection;

- 2-D line intersection quality control statistics;
- Geophysical points quality control statistics;
- Comparison of Coordinate statistics of pre-plotted and post-plotted geophysical points;
- Line position diagram.
- d) Data explanatory documents.

## 9 Data check and acceptance

### 9.1 Check items

#### 9.1.1 Instrument certificate.

#### 9.1.2 Raw data and initial data.

#### 9.1.3 GPS control survey:

- a) Site selection and monument embedment;
- b) Control points tied-surveyed;
- c) Duration of observation session;
- d) Methods of GPS network adjustment and various ways of precision evaluation;
- e) Methods of selecting parameters, computing and utilization;
- f) Height anomaly adjusting or height fitting;
- g) Coordinates system, height system and projection type and zone.

#### 9.1.4 Astronomic azimuth:

- a) Observation method, altitude angle, observation time and observation sets;
- b) Azimuth difference between observation sets.

#### 9.1.5 Traverse:

- a) Traverse station selection, deployment and connection type;
- b) Observation sets, side length, total length, open traverse length, azimuth misclosure, height misclosure and relative precision.

#### 9.1.6 Geophysical points stake out:

- a) Stake out method, accuracy, point interval, point offset;
- b) Geophysical point position MSE, height MSE;
- c) Repeated survey ratio and accuracy of field geophysical points.

#### 9.1.7 Hard-copy data to be submitted:

- a) Survey results and drawings necessary for geophysical data processing and interpretation;
- b) Binding sequence of result logbooks and quality statistics.

#### 9.1.8 Softcopy data:

- a) Data storage format;
- b) Electronic data.

Note: Soft-copy data shall be consistent with the hard-copies.

### 9.2 Result quality evaluation

Survey result quality evaluation shall be classified either by “qualified” or “unqualified”.

#### 9.2.1 Any qualified result shall meet all following requirements:

- The raw field record is required to be complete, objective and readable;
- The various traverse precisions are in compliance with the specified standard;
- The position of the survey line must comply with the geophysical requirements;
- The number of geophysical points whose staking errors are greater than the tolerance shall not exceed 2 percent of the total;
- The number of geophysical points whose point interval errors are greater than the tolerance shall not exceed 2 percent of the total;
- Repeated survey ratio of geophysical points, position MSE and height MSE shall be all in the range of the specified tolerance;
- The submitted items shall be complete and correct.

#### 9.2.2 Any result that meets one or more of the following requirements shall be regarded as unqualified:

- One of the traverse errors exceeds the tolerance;
- The position and length of traverse do not comply with the geophysical requirements;
- The number of geophysical points whose staking errors are greater than the tolerance exceeds 2 percent of the total;
- The number of geophysical points whose point interval errors are greater than the tolerance exceeds 2 percent of the total;
- The repeated survey ratio of geophysical points, position MSE and height MSE exceed the range of the specified tolerance.

**9.3 Acceptance opinion paper**

A check and acceptance report shall be written by the client. The following shall be included:

- a) Operation overview;
- b) References for check and acceptance;
- c) Task description:
  - Survey line length;
  - Full fold length;
  - Number of source and receiver points surveyed and skipped;

——Field check description.

d) Quality description:

- Accuracy of survey line position;
- MSE of Point position and height;
- Other technical aspects.

e) Data sorting:

- Hard-copy data;
- Soft-copy data.

f) Conclusions.

## Annex A (Normative)

### Description of geodetic system

#### A.1 Basic parameters, key geometric and geophysical constants of the ellipsoid for World Geodetic System – 1984 (WGS – 84)

##### A.1.1 Basic parameters of the ellipsoid:

Major radius of ellipsoid  $a = 6\,378\,137\text{ m}$

Earth gravitation constant (including atmosphere)

$$GM = 3\,986\,005 \times 10^8 \text{ m}^3 \cdot \text{s}^{-2}$$

Coefficient of normalized second order zonal harmonics  $C_{20} = -484.166\,85 \times 10^{-6}$

Angular velocity of earth rotation

$$\omega = 7\,292\,115 \times 10^{-11} \text{ rad} \cdot \text{s}^{-1}$$

##### A.1.2 Key geometric and geophysical constants of the ellipsoid:

Minor radius of ellipsoid  $b = 6\,356\,752.3142\text{ m}$

Flattening  $\alpha = 1/298.257\,223\,563$

Square of first eccentricity

$$e^2 = 0.006\,694\,379\,990\,13$$

Square of second eccentricity

$$e'^2 = 0.006\,739\,496\,742\,227$$

Normal ellipsoid gravity potential

$$U_0 = 62\,636\,860.849\,7 \text{ m}^2 \cdot \text{s}^{-2}$$

Normal gravity on equator

$$\gamma_0 = 9.970\,326\,771\,4 \text{ m} \cdot \text{s}^{-2}$$

**A.1.3** WGS 84 (G730)  $GM = 3\,986\,004.418 \times 10^8 \text{ m}^3 \cdot \text{s}^{-2}$ , and other basic parameters, geometric and geophysical constants of the ellipsoid refer to A.1.1. and A.1.2.

#### A.2 Basic parameters, key geometric and geophysical constants of the ellipsoid for Xi'an Geodetic System – 1980

##### A.2.1 Basic parameters of the ellipsoid:

Major radius of ellipsoid  $a = 6\,378\,140\text{ m}$

Earth gravitation constant (including atmosphere)

$$GM = 3\,986\,005 \times 10^8 \text{ m}^3 \cdot \text{s}^{-2}$$

Coefficient of second-order zonal harmonics

$$J_2 = 1\,082.63 \times 10^{-6}$$

Angular velocity of earth rotation

$$\omega = 7\,292\,115 \times 10^{-11} \text{ rad} \cdot \text{s}^{-1}$$

##### A.2.2 Key constants of the ellipsoid in geometry and physics:

Minor radius of ellipsoid  $b = 6\,356\,755.288\,2\text{ m}$

Flattening  $\alpha = 1/298.257$

Square of first eccentricity

$$e^2 = 0.006\,694\,384\,999\,59$$

Square of second eccentricity

$$e'^2 = 0.006\,739\,501\,819\,47$$

Normal ellipsoid gravity potential

$$U_0 = 6\,263\,683 \times 10 \text{ m}^2 \cdot \text{s}^{-2}$$

Normal gravity on equator  $\gamma_0 = 9.780318 \text{ m} \cdot \text{s}^{-2}$

#### A.3 Basic geometric parameters of the ellipsoid for Beijing Geodetic System – 1954

Major radius of ellipsoid  $a = 6\,378\,245\text{ m}$

Minor radius of ellipsoid  $b = 6\,356\,863.018\,8\text{ m}$

Flattening  $\alpha = 1/298.3$

Square of first eccentricity

$$e^2 = 0.006\,693\,421\,622\,966$$

Square of second eccentricity

$$e'^2 = 0.006\,738\,525\,414\,683$$

Annex B  
(Informative)

The format of survey line qualified notice

Surveyed by:

Survey date: from to

Area: line (swath) , line length km,  
stake No. from to ; total points : receiver  
points , shot points , skipped receiver points ; all the above items have been checked,  
approved and applied with the requirements of the relevant geophysical prospecting surveying standards and operation de-  
signs. Thus the operation shall be carried out.

Remarks:  
(Stake numbers for skipped receiver points and retrievable source points are filled in here. )

Signature:

Data processor:

Date:

Chief surveyor:

Date:

Party chief:

Date:

## Annex C

### (Informative)

#### Survey operation design

The design of surveying operation shall consist of:

#### C.1 General

- Task origination;
- Contract number;
- Survey line distribution;
- Operation workload;
- Survey area description.

#### C.2 Operating Schedule

- Operation method;
- Infilling control points plan;
- Geophysical line operation plan etc.

#### C.3 Technical basis

- Surveying standards/specifications;
- Coordinate system, height system, projection and mapping scale for the surveying results.

#### C.4 Technical requirements

##### C.4.1 Technical requirement for geophysical exploration

- Allowable range of receiver point and source point offset;
- Allowable range of receiver interval and source interval;
- Allowable range of the coordinate difference between pre-plotted and post-plotted 2-D line endpoints;
- Allowable range of the coordinate difference between pre-plotted and post-plotted of the receiver points and shot points in 3-D seismic exploration;
- Acceptable range of distance error of the receiver and source interval in 3-D seismic exploration;
- Technical requirements for the skipped points, infilling points and make-up source points;

- The error tolerance and the allowable location range of offset points, full fold points, receiver points and intersecting points in 2-D survey;
- Other technical requirements for geophysical prospecting.

- Other technical requirements for geophysical prospecting.

##### C.4.2 Technical requirements for survey

- Method of control survey and technical requirements;
- Coordinate transformation parameters origination;
- Method of local elevation adjustment and technical requirements;
- Method of geophysical points survey, technical requirements and accuracy specifications.

#### C.5 Personal and equipment

- Personal organization;
- Instrument type, model, and quantity.

#### C.6 Quality assurance

- Key factors affecting the surveying and quality and quality assurance measures;
- Embedment of survey markers and protection measures.

#### C.7 Location of designed survey lines

- Stake number of start and end points, pre-plotted coordinates, azimuths and lengths of 2-D seismic lines;
- Initial point, designed azimuth, operation boundary, single-fold or full-fold boundary, relationships between swaths, stake numbers of start and end points for receiver and shot lines of 3-D seismic lines.

#### C.8 Data processing and result submission

#### C.9 HSE management



## Annex D

### (Informative)

### The format of GPS station description

Date:

Observer:

Draftsman:

Checker:

Point name and type	GPS point	Name		Surface condition	
		No.			
	Adjacent points description (name, number, distance, visibility)		Monument descrip- tion (single/double, new/old, type)		
Location					
Access					
Map number		Approximate coordinates	X	Y	
			L	B	
(Sketch map)                    					
Remarks					

**Annex E**  
**(Informative)**  
**The format of GPS observation logbook**

Project: \_\_\_\_\_

Operator: _____		Date: _____	
Station name: _____		Station No. : _____	
Weather: _____		Session No. : _____	
Station approximate coordinates:		It is a	
Latitude: _____° _____'		_____ new point	
Longitude: _____° _____'		_____ control point	
Height: _____ m		_____ benchmark	
Recording time:		Local time                      UTC                      Time zone:	
From: _____		to _____	
Receiver S/N: _____		Antenna S/N: _____	
Antenna height: _____ m		Post-observation height checked: _____ m	
Pre-observation height measurements: 1. _____ 2. _____		Average: _____ m	
Sketch for antenna height measurement		Station sketch and obstacles around the station	
Remarks:			

## Annex F (Normative)

### Test and maintenance of surveying instruments

#### F.1 Maintenance of optical theodolite and infrared EDM

##### F.1.1 Precautions:

- a) The instrument should be mounted on a tripod and attended by a designated person against damage from passengers and vehicles.
- b) The instrument should be protected from sunshine and rain. An umbrella should be used when the instrument is operated in strong sunshine, rain or dew.
- c) When the instrument becomes wet during operation, it should be dried in a place with good ventilation after operation.
- d) Sitting on the instrument case is forbidden.
- e) Under no circumstances, shall the EDM telescope be aimed directly at the sun, and the distance measure unit should be removed or the transmit/receive lens should be covered with a dark filter when observing the sun azimuth.

##### F.1.2 Transportation and storage of survey instruments:

- a) A person shall be assigned to oversee the daily packing, unpacking and station moving.
- b) During long distance transportation, the instrument shall be placed in a shockproof case and covered with waterproof material. During loading, the instrument must be in upright position and should not be placed upside down. A person shall be designated for the transportation.
- c) The instrument should be stored in a ventilated dry room with good temperature. The instrument shall not be placed close to a stove or heating pipes.
- d) Maintenance shall be periodically fulfilled if the instrument has been idle for a long time.

#### F.2 Maintenance of total station

##### F.2.1 Maintenance of power supply facilities:

- a) To protect the power supply facilities, power plug or data interface shall be inserted or pulled out only when the instrument (total station or PC, etc.) is turned off.
- b) Batteries shall be removed from the instrument when the annual operation is completed or the instrument will not be used for a long time.
- c) During idle period, maintenance procedure shall be fulfilled in accordance with instruction in the user's manual, including maintenance of batteries, the charging period and environmental requirements for maintenance.
- d) The plugs and sockets of the power supply units shall be kept clean.

##### F.2.2 Maintenance of the instrument main unit:

- a) The telescope shall not aimed directly at the sun without a light filter cover.
- b) An umbrella should be used when the instrument is operated in strong sunshine, rain or dew.
- c) The instrument lens shall be capped and the instrument shall be protected with a dust proof cover when operation is completed.
- d) The observation shall stop and the cause should be determined by following the instruction, if the instrument's alarm sounds.
- e) The instrument shall be shut off during thunder and/or lightning.
- f) The instrument's case shall not be used as a seat or base.
- g) The instrument shall be cleaned with a soft brush. The accessory brush supplied with the instrument shall be used to remove the dust when the lens is dirty.
- h) Organic solvent shall not be used for cleaning the monitor, keyboard or its case.
- i) If the instrument becomes wet, it should be dried immediately and more desiccant should be

put in the case.

- j) The internal battery shall be removed before instrument is packed long distance transportation. The instrument and its accessories shall be placed in a specified shockproof box.

#### **F.2.3 Maintenance of accessories:**

- a) The tripod's screws shall be inspected frequently. A screw shall be tightened immediately if it becomes loose.
- b) The setscrews of the prism shall be inspected frequently.
- c) The lens of the prism shall be kept clean.
- d) The screws of the prism pedestal shall be inspected frequently. The setscrews of the tripod base shall be fixed tightly during long distance transportation.

### **F.3 Maintenance of GPS receiver**

#### **F.3.1 General inspection:**

- a) Appearance of receiver and antenna.
- b) Conditions and integrity of parts, accessories, other auxiliary equipment and manuals.
- c) Parts connections.

#### **F.3.2 Inspection after turned on:**

- a) Receiver power connection.
- b) Signal lamps, push buttons and display units.
- c) Self-test.

#### **F.3.3 Retest after check or repairs.**

#### **F.3.4 Establishment of check and files.**

#### **F.3.5 Precautions during transportation:**

- a) The receiver shall be well packed in a box during transportation. Handle gently to avoid

banging, placing upside down and/or heavy loads. A person shall be designated to oversee the transportation.

- b) The receiver box shall be placed properly to avoid collision and falling caused by abrupt start-up, braking or sharp turns during transportation.
- c) The driver shall control the speed.
- d) The antenna shall be stored away from metal when loaded into box and the vehicle, and the cable shall be properly placed.

#### **F.3.6 Storage:**

- a) The keeper shall be responsible for GPS receiver storage.
- b) The receiver shall be cleaned with a soft cloth and brush thoroughly when it is out of operation. The receiver shall be placed in a box with a soft cushion to avoid vibration, humidity, sunshine and dust.
- c) The receiver shall be stored in a ventilated room with good temperature and not be placed close to a stove or heating pipes.
- d) The receiver shall be powered and inspected every one or two months during storage. The instrument shall be charged as required.
- e) The antenna cable used at the site over a long period shall be tested every six months.
- f) The instrument shall not be disassembled, and shall be repaired by qualified workers. When a failure occurs, a detailed accident report shall be written.

**Annex G**  
**(Informative)**  
**GPS control survey report**

A GPS control survey report shall generally include:

- a) Task origination, existing data from the work area, project name, objective, and basic accuracy requirements;
- b) Scope, location, geography, climate, traffic, communication, power supply of the surveying area, etc.;
- c) Surveying crew, work period, personal and technical status;
- d) Surveying technical basis;
- e) Surveying instrument type, precision, test and application;
- f) Site selection and monument embedment;
- g) Observation method, additional survey and resurvey, problem explanation;
- h) Field observation quality analysis and field check results;
- i) Scheme of data processing, software and ephemeris to be used, initial data, coordinate system, minimally constrained adjustment and fully constrained adjustment;
- j) Error test, accuracy estimation of the related parameters and adjusted results;
- k) Description of coordinate transformation and height conversion;
- l) Checking for control point's geoid height through fitting or conversion;
- m) Calculation of coordinate transformation parameters;
- n) Unsolved problems remaining in the survey result, other relative problems, and suggestions for improvement;
- o) All tables and maps;
- p) Survey result list.

## Annex H (Informative)

### Summary of survey operation

When the annual operation is completed, a summary report shall be prepared in accordance with the following:

#### H.1 General

- a) Task origination, contract number;
- b) Location, scope and jurisdiction of surveying area;
- c) Natural environment, geography, traffic, climate and difficulties.

#### H.2 Operation implementation

- a) The date of commencement and finish;
- b) The number of control points;
- c) Completed survey line length and number of geophysical points.

#### H.3 Technical basis for operation

#### H.4 Operation procedure

- a) Deployment of control points;

- b) Operation method;
- c) Operation organization;
- d) Equipment utilization;
- e) Data processing;
- f) Problems and solutions during operation.

#### H.5 Operation quality

- a) Traverse accuracy and error distribution of the weakest points;
- b) Error analysis for the geophysical points;
- c) Verification for resurvey of geophysical points;
- d) Intersection calculation and tie survey;
- e) Difference between pre-plotted coordinate and post-plotted coordinate of the endpoints (include inflexion in 3-D boundary).

#### H.6 HSE implementation

#### H.7 Data submission

#### H.8 Conclusions and recommendation

Annex I  
(Informative)

Data format of seismic survey results

I.1 General

The coordinates and elevation of the geophysical points on the seismic line may be determined by interpolation between surveyed points. The point file shall include coordinates and elevation of all geophysical points (surveyed and interpolated), and permanent markers. The shot point file will be ranked in terms of time, while the receiver point file according to ascending of the line number, point number, and index number. In order to avoid confusion, each receiver point and shot point must have its own exclusive name.

I.1.1 Specification of data record:

- a) A survey SPS data set consists of two files, each with an identical header record, and each ending with 'EOF' (1—3 column);
- b) The first file: receiver point file, including several detailed records of receiver points or permanent markers;
- c) The second file: shot point file, including several detailed records of shot points.

I.1.2 Ranking sequence of complementary data records:

- a) Receiver point file: “R” records, sorted according to line number, point number and in-

dex number.

- b) Shot point file: “S” records, sorted according to shot date (Julian day) and time.

I.1.3 Format of auxiliary data in floppy disk (compact disk).

Specification of floppy disk (compact disk) is composed of:

Code : MS-DOS compatible ASCII files;

Recording length: 80 bytes, followed by a carriage return in column 81 and line feed in column 82;

Filename : filename should be related to the survey area, observation date and ranking, while the extension name related to the file type:

“S” for shot point record, e.g. PRJX90.S01

“R” for receiver point record, e.g. PRJX90.R01

Generally, a file will start with several “header” records followed by “data records”.

I.2 Record specification

I.2.1 Header records

I.2.1.1 General introduction

Each file shall begin with several headers followed by data record. The header shall include relevant information and control parameters of data record.

Format of a header is normally as follows:

Description	Cols	Format
a) Record ID “H”	1	A1
b) Header record type	2—3	I2
c) Header record type modifier	4	I1
d) Description of parameter	5—32	7A4
e) Parameter data	33—80	See example

H0 to H20 in the header are necessary records for all surveys, which can't be omitted even no data entry needed (parameters must be input in H18). Header types H21 to H25 are necessary for the pro-

jection. In projection definition, the application of head blocks is as follows:

Transverse Mercator: H120, H231, H232, H241, H242;

UTM: H19, H220;

Spherical projection: H231, H292, H241, H242;

Oblique Mercator projection: H231, H232, H241, H242, H259 and H256 or H257 or H258;

Lambert conical projection: H210, H220, H231, H232, H241, H242.

Header record type H26 is a free format, statement to express associated information.

### I.2.1.2 Description of header recorders

a) 5—32 cols for parameter description, left justified;

b) 33—80 cols for input parameters, left justified;

Item 1—4Cols	Parameters specification 5—32Cols
H00	SPS format version <b>number</b>
H01	Description of <b>survey area</b>
H02	Date of survey
H021	Post-plot date of <b>issue</b>
H03	Client
H04	Geophysical contractor
H05	Positioning contractor
H06	Pos. Proc. <b>contractor</b>
H08	Coordinate <b>location</b>
H10	Clock time w. r. t. <b>GMT</b>
H11	Spare
H12	Geodetic datum, -- <b>spheroid</b>
H13	Spare
H14	Geodetic datum <b>parameters</b>
H15	Spare
H16	Spare
H17	Vertical datum <b>description</b>
H18	Projection type
H19	Projection zone
H20	Description of <b>grid units</b>
H201	Factor to meter
H210	Lat. of standard <b>parallel (s)</b>
H220	Long. of central meridian
H231	Grid origin
H232	Grid coord. at origin
H241	Scale factor
H242	Lat. , long. scale factor
H256	Lat. , long. initial line
H257	Circular bearing of H256
H258	Quadrant bearing of H256

c) 33—34 cols for codes of instrument, receiver or vibrator;

d) 33—80 cols for free format (12A4) of parameter domain, of which the morphology parting follows the principles as below: comma (,) is used for parameter parting, semicolon (;) for parameters string ending. Each parameter cannot contain any commas ',' or semicolons ';';

e) All distance expressed in meter (s) except grid unit which is defined by H20 and can be transferred into meter by conversion factor of H201.

### I.2.1.3 Necessary header records

Column No.	Parameter format
33—80	12A4
33—80	12A4
33—80	12A4
33—80	12A4
33—80	12A4
33—80	12A4
33—80	12A4
33—80	12A4
33—80	12A4
33—80	12A4
33—80	3A4, 3A4, F12.3, F12.7
33—80	12A4
33—80	3 (F8.3), 4 (F6.3)
33—80	12A4
33—80	12A4
33—80	12A4
33—56	6A4
33—46	F14.8
33—56	2 (I3, I2, F6.3, A1)
33—44	I3, I2, F6.3, A1
33—56	2 (I3, I2, F6.3, A1)
33—56	2 (F11.2, A1)
33—44	F12.10
33—56	2 (F11.2, A1, F6.3, A1)
33—56	4 (I3, I2, F6.3, A1)
33—44	I3, I2, F7.4
33—44	A1, 2I2, F6.3, A1



H259	Angle from skew	33—44	I3, I2, F7.4
H26	Any other relevant information (This record can be repeated as required)	5—80	19A4
H30	Project code and description	33—78	3A2, 10A4
H31	Line number format	33—80	12A4

I.2.1.4 Head block recorder for quality control

Item	Parameters specification	Column No.	Parameter format
1—4cols	5—32cols		
H990	R, S file quality control	33—60	2A4, I4, 4A4
H991	Coord. status final/prov	33—68	4A4, I4, 4A4

I.2.2 Data record

Result record for geophysical exploration survey consists of six domains—recorder ID, line No., point No., point easting, point northing and elevation. The requirement of data column record is in table I.1.

Table I.1: The requirement of data column record

Field	Field definition	Cols	Format	Unit	Comments
1	Recorder ID	1—1	A1	—	R or S
2	Line No. (left justified)	2—17	4A4	—	ID of shot line or receiver line
3	Point No. (right justified)	18—25	2A4	—	ID of shot point or receiver point
4	Point index	26—26	I1	—	Range: 1 to 9, default is 1
5	Point code	27—28	A2	—	Defined in header records, description the character of shot point or receiver point
6	Easting	47—55	F9.1	m	Easting value of H23 with precession down to 0.1m
7	Northing	56—65	F10.1	m	Northing value of H23 with precession down to 0.1m
8	Elevation	66—71	F6.1	m	Elevation of geophysical point with precession down to 0.1m
Note: Point code example: “PM” for permanent marker; “KL” for point to be cancelled or ignored, generally refers to blank point; “G1”, ..., “G9”; “H1”, ..., “H9”; “R1”, ..., “R9” for receiver code; “V1”, ..., “V9”; “E1”, ..., “E9”; “A1”, ..., “A9”; “W1”, ..., “W9”; “S1”, ..., “S9” for shot code.					

I.3 Example of SPS format coding for seismic survey data

I.3.1 SPS file for receiver point

## R FILE

H00 SPS format version num.	SPS001, 08Oct1990 (SHELL EP 90-2935);							
H01 Description of survey area	China, stm well area of tarim, xinjiang;							
H02 Date of survey	start : 2001.05.14-end : 2001.05.14;							
H021 Post-plot date of issue	05/14/2001;							
H03 Client	ta zhi;							
H04 Geophysical contractor	BGP1;							
H05 Positioning contractor	BGP1;							
H06 Pos. proc. contractor	BGP1;							
H08 Coordinate location	Center of source and of receiver pattern;							
H10 Clock time w. r. t. GMT	- 8;							
H11 Spare								
H12 Geodetic datum, - spheroid	BEIJING 54 6378245.000 298.3000000							
H13 Spare								
H14 Geodetic datum parameters	15.800 - 154.400 - 82.300 0.000 0.000 0.000 0.000							
H15 Spare								
H16 Spare								
H17 Vertical datum description	HUANGHAI SYSTEM, QINGDAO SHANGDONG, CHINA;							
H18 Projection type	TM;							
H19 Projection zone	15;							
H20 Description of grid units	METERS;							
H201 Factor to meter	1.00000000							
H210 Lat. of standard parallel (s)	0.0000N							
H220 Long. of central meridian	81.0000E							
H231 Grid origin	0.000N81.0000E							
H232 Grid coord. at origin	500000.00E0.00N							
H241 Scale factor	1.0000000000							
H242 Lat. , long. scale factor	0.0000N81.0000E							
H256 Lat. , long. initial line								
H257 Circular bearing of H256								
H258 Quadrant bearing of H256								
H259 Angle from skew								
H26	H14 Datum transformation from Everest to WGS-84;							
H26	Local Map Coord. Grid = Easting values + 15000000m;							
H30 Project code and description	STM 3-D KANTAN;							
H31 Line number format								
H990 R, S file quality control	05/14/2001, 0100, MR. LIU;							
H991 Coord. status final/prov	Final, 10/3/01, 1600MR. YUAN;							
H26	567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
H26	1	2	3	4	5	6	7	8
RSTM125			2691G1		259573.5	4582662.9	929.3	
RSTM125			2701G1		259574.8	4582702.8	930.3	
RSTM125			2711G1		259576.1	4582742.9	931.0	
RSTM125			2721G1		259577.3	4582782.8	929.4	
RSTM125			2731G1		259578.7	4582822.9	928.9	
RSTM125			2741G1		259579.8	4582862.8	929.2	

RSTM125	2751G1	259581.0	4582902.7	929.2
RSTM125	2761G1	259582.4	4582942.6	929.0
RSTM125	2771G1	259583.8	4582982.7	928.9
RSTM125	2781G1	259584.9	4583022.6	928.8
RSTM125	2791G1	259586.3	4583062.8	929.1
RSTM125	2801G1	259587.5	4583102.7	929.7
RSTM125	2811G1	259588.6	4583142.6	929.2
RSTM125	2821G1	259589.9	4583182.6	929.3
RSTM125	2831G1	259591.3	4583222.7	929.5
RSTM125	2841G1	259592.5	4583262.7	927.6
RSTM125	2851G1	259593.7	4583302.5	929.0
RSTM125	2861G1	259595.2	4583342.7	929.0
RSTM125	2871G1	259596.4	4583382.5	928.9
RSTM125	2881G1	259597.6	4583422.6	927.7
RSTM125	2891G1	259599.0	4583462.6	928.0
RSTM125	2901G1	259600.2	4583502.6	928.0
RSTM125	2911G1	259601.5	4583542.5	927.4
RSTM125	2921G1	259602.8	4583582.4	927.8
RSTM125	2931G1	259604.1	4583622.4	927.5
EOF				

I.3.2 SPS file for shot point

S FILE	
H00 SPS format version num.	SPS001, 08Oct1990 (SHELL EP 90 - 2935);
H01 Description of survey area	china, stm well area of tarim, xinjiang;
H02 Date of survey	start: 2001.05.14 - end : 2001.05.14;
H021 Post-plot date of issue	05/14/2001;
H03 Client	ta zhi;
H04 Geophysical contractor	BGP1;
H05 Positioning contractor	BGP1;
H06 Pos. proc. contractor	BGP1;
H08 Coordinate location	Center of source and of receiver pattern;
H10 Clock time w. r. t. GMT	- 8;
H11 Spare	
H12 Geodetic datum, - spheroid	BEIJING 54 6378245.000 298.3000000
H13 Spare	
H14 Geodetic datum parameters	15.800 - 154.400 - 82.300 0.000 0.000 0.000 0.000
H15 Spare	
H16 Spare	
H17 Vertical datum description	HUANGHAI SYSTEM, QINGDAO SHANGDONG, CHINA;
H18 Projection type	TM;
H19 Projection zone	15;
H20 Description of grid units	METERS;
H201 Factor to meter	1.00000000
H210 Lat. of standard parallel (s)	0.0000N
H220 Long. of central meridian	81.0000E

H231	Grid origin	0.000N81.0000E
H232	Grid coord. at origin	500000.00E0.00N
H241	Scale factor	1.0000000000
H242	Lat., long. scale factor	0.0000N81.0000E
H256	Lat., long. initial line	
H257	Circular bearing of H256	
H258	Quadrant bearing of H256	
H259	Angle from skew	
H26		H14 Datum transformation from Everest to WGS-84;
H26		Local Map Coord. Grid = Easting values + 15000000m;
H30	Project code and description	STM 3-D KANTAN;
H31	Line number format	
H990R	S file quality control	05/14/2001, 0100, MR. LIU;
H991	Coord. status final/prov	Final, 10/3/01, 1600MR. YUAN;
H26	567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890	
H26	1 2 3 4 5 6 7 8	
SSTM125.5		95.51E1 259627.0 4583721.4 929.5
SSTM126.5		295.51E1 259666.9 4583720.2 929.4
SSTM115.5		295.51E1 259227.1 4583734.0 929.0
SSTM127.5		295.51E1 259707.0 4583718.9 928.9
SSTM116.5		295.51E1 259267.2 4583732.8 929.6
SSTM128.5		295.51E1 259747.0 4583717.6 928.4
SSTM117.5		295.51E1 259307.4 4583731.5 930.3
SSTM129.5		295.51E1 259787.0 4583716.4 928.1
SSTM118.5		295.51E1 259347.2 4583730.3 929.5
SSTM130.5		295.51E1 259826.9 4583715.0 928.4
SSTM119.5		295.51E1 259387.2 4583729.0 927.3
SSTM131.5		295.51E1 259866.9 4583713.8 929.0
SSTM120.5		295.51E1 259427.3 4583727.7 929.2
SSTM132.5		295.51E1 259907.0 4583712.7 929.0
SSTM121.5		295.51E1 259467.0 4583726.6 929.2
SSTM122.5		295.51E1 259507.1 4583725.2 929.5
SSTM114.5		295.51E1 259187.2 4583735.4 929.5
SSTM116.5		308.51E1 259283.7 4584252.8 928.9
SSTM125.5		308.51E1 259643.6 4584241.2 927.8
EOF		

Annex J  
(Informative)  
Format of seismic survey results

J.1 Format of technique statement

Technique statement

Crew No.		Area		Date	
Instrument					
Applicable technical standard			Mapping scale		
Coordinate system			Elevation system		
Quantity of control points			Quantity of traverse	line, km	
Quantity of lines	line	Traverse		km	
	km	RTK		km	
Quality of traverses	Position MSE	± m	Survey quality of geophysical points	$m_x = \pm$ m	$m_y = \pm$ m
	Elevation MSE	± m		$m_h = \pm$ m	

Note1: Position MSE (mean square error) of traverse points  $m_s = \frac{1}{2} \sqrt{\frac{[f_s^2]}{n}}$   
 $n$  represents the number of traverse misclosures.

Note2: Elevation MSE (mean square error) of traverse points  $m_h = \frac{1}{2} \sqrt{\frac{[f_h^2]}{n}}$   
 $n$  represents the number of traverse misclosures.

Note3: Northing MSE (mean square error) of geophysical points  $m_x = \sqrt{\frac{\sum_{i=1}^n (\Delta x_i)^2}{2n}}$

$$\Delta x_i = x_i - x'_i$$

$x_i$  is the northing of repeated points,  $x'_i$  is the northing of surveyed points,  $n$  is the total number of geophysical points.

Note4: Easting MSE (mean square error) of geophysical points  $m_y = \sqrt{\frac{\sum_{i=1}^n (\Delta y_i)^2}{2n}}$

$$\Delta y_i = y_i - y'_i$$

$y_i$  is the easting of repeated points,  $y'_i$  is the easting of surveyed points,  $n$  is the total number of geophysical points.

Note5: Elevation MSE (mean square error) of geophysical points  $m_h = \sqrt{\frac{\sum_{i=1}^n (\Delta h_i)^2}{2n}}$

$$\Delta h_i = h_i - h'_i$$

$h_i$  is the elevation of repeated points,  $h'_i$  is the elevation of surveyed points,  $n$  is the total number of geophysical points.

J.2   Format of statistics of difference between post-plotted coordinates and pre-plotted coordinates for 2-D (3-D) line endpoints

Statistics of difference between post-plotted coordinates  
and pre-plotted coordinates for 2-D (3-D) line endpoints

Line No.	Point No.	Point code	Post-plotted coordinates		Pre-plotted coordinates		Difference			Remarks
			x	y	x	y	$\Delta x$	$\Delta y$	$\Delta s$	

Prepared by:Checked by:

Notes: Coding example:

R—receiver endpoint;  
S—shot endpoint;  
O—single fold endpoint;  
F—full fold endpoint.

J.3   Format Of 2-D line checking quality control statistics for intersection

2-D Line checking quality control statistics for intersection

Second-survey line No.	First-survey line No.	Point Results of second-surveyed line				Point results of first-surveyed line				Difference		Remarks
		Point	x	y	h	Point	x	y	h	$\Delta s$	$\Delta h$	

Prepared by:Checked by:

Notes:  $\Delta s = \sqrt{\Delta x^2 + \Delta y^2}$

J.4   Format of survey quality statistics for traverse

Survey quality statistics for Traverse

Line name	Traverse length	Azimuth misclosure		Elevation misclosure		Relative precision		Associated lines
		Tolerance	Surveyed	Tolerance	Surveyed	Tolerance	Surveyed	

### J.5 Format of survey quality statistics for seismic line

## Survey quality statistics for seismic line

[illegible]

Prepared by:

Checked by:

中华人民共和国  
石油天然气行业标准  
**石油物探测量规范**  
SY/T 5171—2003

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