Medical Electron
Linear Accelerator

Guidelines for
Accelerator Rooms design

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Contents

Chapter.1 Introduction

This guidelines falls into two parts: The primitive data and Guidelines for accelerator room design. The primitive data are based on the international standard rules in Radiotherapy Accelerator Facilities. Shinva Medical (Radiotherapy manufactory) provides hospital (our customer) with relevant information, and we take responsibility for our information.

According to the international practice, the actual legal requirement for the place where the facilities will be established should be determined at an early planning stage. A qualified expert and governmental authorities should be consulted during the designing calculation of the treatment room, and the drawings should be submitted for review and approval by governmental authorities before construction begins. Manufactory doesn't bear responsibility for the problems occurred during the constructing process. As following aspects concerned:

1) Radiation protection standards may vary in different locations and are revised from time to time;
2) The workloads (busy degree) of each hospital are different;
3) The available lands of building are different;
4) The auxiliary equipment, such as simulator and brachy therapy equipment etc, and their emplacement may differ from each other.

So the layout of treatment room, shielding calculation and relevant matters are only offered as reference. Hospital (our customer) should keep in mind to offer this guide to the architect.

Chapter.2 Design thinking of the Accelerator Room

2.1 The shielding purpose and principle rules

The bad effects ionizing radiation from X-ray can be divided into two kinds: stochastic effects and deterministic effects. The shielding purpose is to protect radiotherapy staff and general public (of their max dose) from reaching the threshold of deterministic effects, and also constraint the possibility of stochastic effects in a receivable and reasonable range (as low as possible).

Three basic principles are adopted here, including justification in practice, optimization shielding and personal/individual dose limits. Here optimization indicates gaining maximal pure profit at the lowest cost, but not pursuing the decrease of the dose limits unlimitedly and blindness.

2.2 Choosing of shielding materials

To constraint the leakage dose below 0.1% of the useful beam, high-Z-number materials are used in the collimator of accelerator, such as depleted uranium, tungsten, and lead. Meanwhile, the material used to build the treatment room is of cheap kind normally, which is also can be constructed conveniently. To reduce the cost of land for building in the downtown, iron ore, barite, or cast iron is introduced to the shielding wall which can minish its thickness aptly.

2.3 Terminology and Symbols

2.3.1 Terminology

Useful beam: the ionization radiation through the collimator.

Leakage radiation: the beam beyond the useful beam from the collimator.

Scatter radiation: the radial reflected from the objects been irradiated.

Stray radiation: includes leakage radiation and scatter radiation.

Primary barriers: the ceiling and walls being irradiated by the useful beam (as the useful beam is much more than the leaked and scatter radiation, the latter radiation is ignored in the calculation of primary barriers).

Secondary barriers: the ceiling and walls, which cannot be irradiated by the useful beam, it is taken over to calculate the shielding of the leaked and scatter radiation).

2.3.2 Working Site

The working site can be divided into three parts: Controlling area, monitored area and non-ionization area. According to the ICRP-60, GB18871-2002 provision, H_{la} indicates the annual permissible exposure levels; H_{LW} indicates the weekly permissible exposure levels, while H_{Lh} indicates the hourly permissible exposure levels. Relevant criteria are shown in the following table.

Dose equivalent / Site	H_{la}	H_{LW}	H_{Lh}
Controlling area（occupationally exposed）	20mSv·a^{-1}	0.4mSv·W_k^{-1}	10μSv·h^{-1}
Non-ionization area (Non-occupationally exposed)	1mSv·a^{-1}	0.02mSv·W_k^{-1}	0.5μSv·h^{-1}

2.3.3 Workload---W

For radiation therapy, it is customary to express the equipment workload W in Gy(rad) per week produced at 1 meter from the therapy unit target (Gy(rad).m^2 .W_k^{-1}).(Some times, Sv is used instead of Gy , they are ilk in numerical value. So they are exchangeable in calculation).If 50 patients will be cured one day, 1000 Gy · m^2 · W_k^{-1} is available, if 100 patients cured, just twice.

2.3.4 Occupancy factor---T

The area occupancy factor T is meant to take into account the average time per 40-hour workweek spent by any individual in the occupied areas to be shielded. The value T=1 is used for the entire controlled area, including adjacent radiation rooms if designed to be occupied while the accelerator in question is operated. Frequently occupied outside of the controlled area, such as offices, laboratories, shops, living quarters and nearby buildings, are also ascribed T=1. Areas expected to be occasionally used by individuals, such as corridors, waiting rooms and elevators, may be ascribed T=1/4. For areas outside of the controlled area but within the institution's grounds, where it can be ensured that no individual does remain more than a small fraction of the time, an occupancy factor T=1/16 is recommended. Public areas where it is clearly unreasonable to expect that any individual would consistently linger more than, say, two hours per week (such as streets, sidewalks, parking lots or lawns) may also be ascribed T=1/16.

2.3.5 Orientation (use) factor ---U

The orientation factor (use factor) U is used to account for the average fraction of the accelerator "on-time" for which the radiation is directed towards a given barrier. For facilities where there is no provision for changing the beam direction, there is a single primary barrier; the orientation factor associated with it is U=1. Since secondary barriers *always* protect against stray radiation, regardless of beam direction, they are also ascribed an orientation factor U=1. Where the useful beam orientation is changeable, orientation factors less than 1 may be used for those primary barriers that are less frequently used (see the following table for suggested orientation factors for radio therapeutic facilities). Specific factors for radio therapeutic facilities are also given in NCRP Rep.No.49 [4].

Type of Barrier	Type of Radiation	Value of U
Primary Barrier		
Floor	Useful beam	1
Walls toward which useful beam can be directed	Useful beam	1/4
Ceilings	Useful beam	1/4
Areas towards which useful beam is directed only in moving-beam therapy	Useful beam	1/10
Secondary Barriers	Leakage radiation	1
	Scattered radiation	1

2.3.6 Safety factor---n

For the final design, it is a good practice to then augment the preliminary design by a safety factor of two, in the form of an additional HVL of shielding material on all sides. The additional expense involved in providing a safety factor of two for new construction is relatively small compared with other installation costs, and much less than later modifications or forced reductions in operation would be.

2.4 Calculation of X-ray Shielding

2.4.1 Symbols explain

d: Distance between the target and the nearest point of the area to be protected (m);

d1: Distance between the target and nearest scattering object (m);

d2: Distance between scattering object and the nearest point of the area to be protected (m);

d3: Distance between backscattered radiation object and the nearest point of the area to be protected (m);

S、S'：S and S' stand for the areas on the concrete walls, ceilings or floors irradiated by the useful beam and/or leaked beam visible from the nominal shielding point(m^2);

K：Attenuation factor (dimensionless);

K_L：Attenuation factor concerning of leaked radiation;

K_S：Attenuation factor concerning of scatter radiation.

2.4.2 b. Primary shielding against the treatment beam

$K=W\ (Sv\cdot m^2\cdot W_k^{-1})\ \cdot U\cdot T\cdot n/H_{LW}\ (Sv\cdot W_k^{-1})\ d^2\ (m^2)$

$=W\times U\times T\times n/\ H_{LW}d^2$

Parameters in the brackets have dimensions in the formulae, while U、T、n、K are dimensionles.

2.4.3 Shielding of leakage radiation

We (manufacture) guarantee the criterion (the average leaked radiation should be constraint under 0.1% of that in the axis of the useful beam) that the leakage at a reference point with a beam stopper in the radiation head. Thus W_L should be W/1000，

$K_L=W_L\ (Sv\cdot m^2\cdot W_k^{-1})\ \cdot T\cdot n/H_{LW}\ (Sv\cdot W_k^{-1})\ d^2\ (m^2)\ =W_L\times T\times n/\ H_{LW}d^2$

As medical accelerators discussed here, the dose of scatter radiation from patient and couch faceplate should not exceed the leakage dose. Meanwhile, as scatter radiation is less penetrating than the leakage radiation, it is mainly taken into account in the confirmation of thickness of the secondary shielding.

2.4.4 Shielding of scattered photons

Photons scattered by objects in the direct bremsstrahlung beam must be considered in the calculation of shielding barrier thickness, as well as in the design of labyrinths and ducts. The amount of radiation scattered is proportional to such factors as the radiation intensity incident on the surface and the area of the surface irradiated, and it is inversely proportional to the distance from the irradiated surface to the location in question. These factors are multiplied by a dimensionless coefficient α, called the differential dose albedo, which depends on the photon energy spectrum, the type of material irradiated, the angle of scattering, and the orientation of the surface.

$K_S=（S\cdot W+S'\cdot W_L）\alpha/d_1^2\cdot d_2^2\cdot H_{LW}\cdot 100$

2.4.5 Adequate precision of K and K_L can be ensured in the following table.

Table 1 Concrete (ρ=2.35g/cm^3) thickness needed for different attenuation coefficient when 6MV radial used

K	Thickness	K	Thickness
1.5	7	500	94
2	12	$1\cdot10^3$	103
5	26	$2\cdot10^3$	114
8	33	$5\cdot10^3$	126
10	37	$8\cdot10^3$	134
20	47	$1\cdot10^4$	138
30	53	$2\cdot10^4$	148
40	58	$5\cdot10^4$	161
50	60	$1\cdot10^5$	171
60	63	$2\cdot10^5$	181
80	67	$5\cdot10^5$	194
100	70	$8\cdot10^5$	203
200	80	$1\cdot10^6$	205

Table 2 the ratio of concrete to lead and steel（6MV X-ray used）

Corresponding thickness (mm) of concrete instead of 1mm lead/steel

Steel	Main shielding	3.5
	Secondary shielding	3.5
Lead	Main shielding	6.2
	Secondary shielding	6.2

2.4.6 As following aspects concerned, it is difficult to calculate Ks accurately.

1) Lack of data about the scatter coefficient;
2) Area integral should be carried out through all the little units（as a，d_1，d_2 in the formulae are not same）；
3) The existence of backscattered radiation, multiple scattering. The intensity and energy of multiple scattering decreases sharply, so does the penetrability;
   Result from experimentation shows that energy of scattered photons does not decrease proportional to the squared distance.
4) But in actual utilities, calculation has never been carried out, while following measures adopted in stead:
   a) Perfectly designed labyrinths been used, such as multi-folded labyrinth of S-shaped, U-shaped and UL-shaped, they are all better than the single-folded labyrinth， this is because of the rays can reach the door only after multiple scattering. Meanwhile it is necessary that when standing at the door, it is invisible of the ceiling and walls been irradiated by the treatment beam.
   b) To reduce the area of section is propitious to decrease the scattered radiation, but this is at the cost of reducing the convenience of access, especially for hospital gurneys and equipment to be installed just like the multi-folded labyrinth.
   c) To gain further attenuation of radiation and guarantee the standard radiation shielding requirement outdoors, the shielding door should be covered with a layer of thick lead.

2.4.7 The secondary barriers

Two sources of photon radiation must be considered in the design of secondary barriers simultaneously: Bremsstrahlung at wide angles (the ‘leakage’ radiation of radio therapeutic or radiographic units is dominated by wide-angle bremsstrahlung) and photons scattered from objects placed in the direct bremsstrahlung beam. If the two thicknesses differ by less than one 1/10 HVL (for bremsstrahlung), one additional HVL (for bremsstrahlung) should be added to the calculated thickness. If they differ by more than one (including one) HVL, the bigger one should be used.

2.4.8 Two viewpoints

There are two viewpoints international existed now. One side insists that the annual dose equivalent of personnel should be decreased. While the opposite insists that small dose radiation will do good to human health by enhancing the immunity ability. They drew this conclusion on the basis of the facts from the last several decades. For example, the health condition of the inhabitants who received small radiation from the A-bomb and the personnel who engaged in A-bomb or nuclear energy study is better than the average.

2.4.9 Optimization in shielding:

When thick shielding is designed, heavy investment is needed；While thin shielding is designed; the dose equivalent and the venture of health hazard will increase. The optimized design can minimize the total expense of shielding and health damage. The dose equivalent will not decrease much as expected when the thickness is added blindly. But if weak spots (such as straight hole) exist in the design, the dose equivalent will increase sharply.

Chapter.3 Primitive Data of the Accelerator Facilities

Medical linac XHA600C radiates only one kind of X-ray.

1. This kind of X-ray has a continuous spectrum, energy of the peaks in the spectrum is 6MV (that is to say, the energy of accelerated electron is 6MeV). SAD＝100cm.
2. When 10cm×10cm irradiation field being used, the absorbed X-ray penetrability dosage 10cm under water at the nominal treatment distance (100cm of the useful beam) as defined in IEC, its quantity is about (67±3) % of the $dose_{max.}$
3. At normal treatment distance (100cm), the nominal dosage absorbed is 2.5Gy/min. It is possible that the new equipment will have a higher energy and output than this criterion. On the safe case, 3Gy/min can be adopted into the shielding calculation.
4. At normal treatment distance (100cm), the max irradiation field is 40cm×40cm. （primary-collimating angle of 2×13.9 ° can be adopted into the shielding calculation）
5. The gantry can revolve 370 ° around the main axis, and the direction of radiation beam is changeable.
6. The max leakage dose should be constraint less than 0.1% of the main beam normally.
7. As this accelerator belongs to the low-energy series, the neutron effect and induced radiation can be ignored in the shielding calculation, as well as the radiation from the oxygen and nitrogen been activated.

Chapter.4 The Overall Design Requirement of Accelerator Room

4.1 Structure and layout

1. Because of the weight of shielding barriers, a ground-level location is preferred for radiation facilities. If this is not possible/available, construction must be given to the problem of structural support. Its space should be no less than 36 m^2. Basement is not preferred here, because it is necessary to transport in the accelerator before the building is completely constructed if such a room is chosen. Meanwhile, the damp will corrupt the machine stored in such environment in a long term, and it is inconvenient to update the equipment in one or two decades.
2. To satisfy the normal work of the accelerator need three rooms, treatment rooms, a control room and auxiliary engine room. Room layout and size of the main planning and design; see Figure 1 (room layout map, Page19). One treatment room area has been taken into account total body irradiation method needs the control room area of not less than 13 m^2; auxiliary engine room should be not less than 10 m^2. At the same time users in the design room should also consider simulator rooms, radiation physics room, waiting room, office, examination room, maintenance work, and assorted space settings

4.2 Shielding requirements (see P19-21 Figure 1, 2, 3)

1. Careful mixing and pouring of close-grained concrete are important to ensure uniformity and to prevent settling of the high-density filler. No cavum and gap should exist, and the density should be no less than 2.35g/cm3. Checking-up work should be carried occasionally during the constructing period, and pre-set pipes should not be ignored.
2. None pipeline is permitted to pass through the shielding straightly. Compensating measures should be carried out in weak spots where shielding ability is decreased by the pipelines for ventilations and cables.
3. Windows could not to be designed in the treatment room, neither at other places where shielding ability may be decreased.
4. The shielding door should be larger than the door cavity, so that the joints (no less than 100mm on one side) between walls and door are adequate to reduce the leakage of radiation.

4.3 Power requirement

1. None of the following facilities should be linked onto the special switchboard for the accelerator:
   a) Electromotor
   b) Air conditioner
   c) Elevator
   d) General facilities
2. Requirement for power supply system
   a) Wire material: Copper wire is permitted here, aluminum wire never used.
   b) Power data：

Source voltage	380V±38V;
Frequency	50Hz±1Hz;
Input power	30kVA;
Current	45A;
Line voltage	380V;
Voltage fluctuation	≤±10%;
Phase balance	3% between any 2 phases Maximum;
Power load	20kVA;
Power factor	≥90%;

Remark: Single power supply with three-phase five-wire system (3 wire power, neutral and separate ground all the same wire gauge).

If the accelerator powered supply with the **stabilized voltage supply** (optional),it's output voltage variation must **No more than** ±3% Maximum (either loaded or unloaded);

4.4 Safety interlock requirements

To ensure the safety of staff, XHA600 Accelerator a safety interlocks circuit. See XHA600 type accelerator room interlock wiring diagram (P27).

4.5 Temperature and humidity requirements

To ensure the normal operation of accelerators, treatment rooms, the control room, the room temperature should be assisted in 20℃ -25℃, and the relative humidity should be between 30% -75%.

4.6 Ventilation requirements

When the accelerator is routinely running, the production of bit toxic gases such as ozone and nitrogen oxide is observed (without radioactive gases). And seldom SF_6 gas will be produced during the repairing of microwave system. If the accelerator sparks frequently, toxic gas will be decomposed from SF_6 by the arc, the gas must be discharged by the ventilating system.

4.7 Grounding safety requirements

A fixed grounding system separated from neutral should be offered to link the ground directly and perfectly.

1. **The resistance of the grounding system should be no more than 0.4Ω.**
2. Ground wire：The ground wire must be an insulated, stranded, copper conductor of the same wire gauge and type as the phases and neutral, continuous in length, stemming from the ground side of the neutral to ground bond point of the required conditioning step-down transformers (the separately derived source)
3. The importance of a single power and ground source for microprocessor controlled therapy equipment cannot be over-emphasized. Multi ground paths or events from other power source are easily imported into microprocessor equipment by data cables and control circuits that interconnect equipment subsystems.
4. **A copper bolt (M10) should be welded on the linkable end of the grounding system, and this end should be stretched to the L-shaped groove behind the base of accelerator.**

Chapter.5 The Specific Design for Accelerator Room

5.1 Treatment room (see Perspective Room P22-23)

5.1.1 Pit design

1. Figure of delve/pit and foundation of the accelerator(see P20)
2. Figure of delve and foundation for the main part of accelerator(see P21)
3. Thickness of base for accelerator in the treatment room should be no less than 200mm, the compressive strength should behigher than 20MN/m2（2800pound/inch2）, and finally the horizontal error on the cater corner should be limited in the range from -5mm to +5mm.
4. Base of the accelerator (offered by Inhaul) should be buried when the concrete floor is poured in the treatment room. The location of base in the pit and the eventual orientation work should be supervised by the installation engineers from Inhaul, and assisted by the `Porters` employed by customer. The sunken sits of the pit should be poured with concrete after the base is located and the horizontal error is guaranteed.
5. As to the ordinary concrete （2.35g/cm^3）, the shortest maintenance period should be seven days, and the compressive strength will reach 141kg/cm^2.
6. Within the scope of 1800mm around the center, the evenness error between floor and the top of the base should be controlled in the range from -3mm to +3mm.

5.1.2 Labyrinth, the protective doors and floors Design

1. The height (more than 2.5m) and width (more than 1.8m) of labyrinths and shielding door should be convenient for the transportation and inlet of accelerator. So does the path between the unpacking place and the treatment room.
2. Experienced `Porters` are required to inspect on-site with a transportation sample to make sure that empty space is preserved for transportation. The transportation sample should be able to pass through the labyrinths and not touch the walls. To in-let the moving work pieces conveniently, the floor should be designed to bear the heaviest loads contemplated.
3. Figure of the main part's transportation route (page 32)
4. Figure of the profile of the transportation dolly (page 26)

5. As the machine is placed on the dolly and pushed into the room by labor power, an eyebolt of 10-ton capacity for traction at the labyrinth corners should be designed on the walls opposite the labyrinths gate so that the machine can be moved in conveniently.(see page31 A-A)
6. An interlock switch should be installed on the shielding door so that the beams can only be produced when the door is closed and if any person breaks into the room, the irradiation will terminate at once. The interlock should be installed along with the door; two wires placed through the buried cable conduit (See room online support facilities threads pipeline maps, P28) are used to connect the “normal open”. These wires should be stretched to the groove and 3 meters lengthened lines are needed for the future linkage up to TB1-7，8 on the main board by our engineers.
7. Protective doors protective capacity of not less than 6 mm lead equivalent. Proposed the installation of doors manually switching devices and infrared devices.
8. Two lights over the door should be installed, a green one for warning of irradiation "READY" and a red one for warning of irradiation "ON". three wires should be placed through the conduit(See room online support facilities threads pipeline maps, P28)and stretched to the cable groove under the main body, three meters' extra lengthened lines should be prepared for the linkage to TB1-10、11、12 on the main board.

5.1.3 Cable Ditch design (See P19 treatment room layout)

1. Cable Ditch: Cable conduits designed in the auxiliary room, control room and treatment room are used in laying the cable lines or water pipes among the rooms.
2. Cable ducts: Three pipes larger than ф100 in diameter should be buried between the treatment room and control room (cable conduits nearside are preferred to be connected). Oblique (in the horizontal plane) pipelines are preferred to reduce the scattered radiation.
3. Bending radius 6 times of the diameter is commended to use for cable pipes if any pipe needed to be bended in laying. The total bending angle of the cable pipe should not exceed 270°。
4. Temporary cable pipes for dosimeter and three-dimension water tank are preferred between the treatment room and control room to avoid blending with the permanent cable conduits.
5. A copper (or stainless steel) pipe of 1-inch diameter from the water chiller in the auxiliary room to the rear face of the accelerator should be buried in advance so that the inflow

and outflow of constant temperature water can be guaranteed, U-shaped is preferred here. To minish the radiation, the lower part should be buried underground. Treatment of indoor plumbing to increase ball valves, fittings for ZG1 "in the thread.

5.1.4 Crane and crane beam design (see room elevation, P20)

A steel beam of I-shaped (25b) should be placed over the accelerator and should be across the axis of the gantry. A railed manual crane and a two-ton manual elevator can be installed on the beam so that it can be convenient to install and maintain the machine. The crane and elevator is preferred to preserve at the original place for later maintenance.

5.1.5 Lighting System

Respectively with the main light, background light, emergency light, maintenance light, the corridor lights, and other five lights. In the accurate patient positioning process, lights in the treatment room should be dimmed down so that the projection of field lamp and range finder can be observed clearly. That is to say when is on, the field lamp and range finder should be shut off and when the process is finished, they reset by themselves. Down-leads should be placed through the conduit (not marked on the figure, it can be sketched by customer accordingly) and stretched to the cable groove under the main body, three meters' extra lengthened lines should be prepared for the linkage to TB1-3、4 on the main board.

5.1.6 The design of the ventilation system

1. The stomata of the ventilation should be placed far from the labyrinths. (see I-I room elevation P20) As the specific gravity of ozone is larger than average, the stomata of the ventilation should be as close as possible to the floor. The pipelines of ventilation should be configured as labyrinths, with the biggest section area no less than 0.25m^2。 An air pump is necessary at the stomata of the ventilation on the outside of the treatment room. The capacity of the turbine should be able to guarantee the lowest command of air changes of the treatment room 3～4 times in one hour in routine running. Relevant compensation should be made at the places on the walls (or roof) where shielding ability is attenuated. Wire netting should be added on the stomata to keep rats from entering the rooms.
2. Stomata for wind inlet should be designed near the labyrinth gate, on the roof or above the walls over the gate.（see II-II Room Elevation P27）。To constraint the radiation at the minimum dose in the reachable area, the pipelines should be installed as high as possible.

In the design of ventilation the section area (no more than 0.25m2) through the walls should be minimized. Pipelines for wind inlet should be designed as labyrinth-shaped. Relevant compensation should be made at weak spots on the walls (or roof) where shielding ability is decreased by wind inlet pipes.

3. Stomata for wind inlet should be able to filter most particles whose diameter is larger than 10 μ m.

5.1.7 Heating and dehumidification Design

1. The proposed allocation of the treatment room air conditioners, dehumidifiers. To maintain the temperature at 20℃ to 25℃, and the relative humidity is 30% -75%. Not only patients feel comfortable, and it is not overheating and equipment too wet.
2. **Room when planning the construction of the air-conditioning installation, embedded good corresponding pipeline.**

5.1.8 Other ancillary equipment (see Figure P29 to P32)

5.1.8.1 Laser positioning lights (optional):

Two on opposite walls (1340mm from finished floor) and a third one high (typically 2300mm from finished floor) on the wall at the target end of the linac, project a vertical fan beam through the gantry axis and all the three through isocenter. Three electrical outlets of 220V power supply should be prepared, two of them (on the side walls) be placed 1.1m from the finished floor and the third one 2m. One switch 1.3m from finished floor for controlling of these lamps should be placed on the side wall close to the labyrinth and the down lead stretched to the fossa under the main body with a cable conduit, just like the diagram illustrates. And 3 meters lengthened lines should be prepared for future installation, they will be linked up to TB1-1, 2 on the main board.

5.1.8.2 Emergency off-switches:

Beyond the emergency off-switches on couch, consol and stand,1--3 emergency off-switches should be installed on proper places easy to touch in the treatment room and labyrinths （we offer one at the booking time, others should be bought by customers themselves） .They can shut off the beam and relevant movements, but the following should never be shut off emergently: the motor used for driving the shielding door, lamps in the treatment room, and interlocks for safety cases. The emergency off-switches should be distinguished clearly and easily buttoned, but not easily touched involuntary, nor should it be reset automatically. When several emergencies off-switches are used, they should be arranged in series. cable conduit should be buried in advance during the capital construction (figure d), lines linked up and switch installed (1.3m above the ground)， two wires should be placed through the conduit(figure e)and stretched to the cable groove under the main body, three meters' extra lengthened lines should be prepared for the linkage to TB1-5、6 on the main board.

5.1.8.3 Camera (optional):

Best visual field should be ensured when the pickup camera is installed(normally located above and at an angle of approximately 15° off the gantry axis of the accelerator, last places should be ascertained according to the actual case), meanwhile, camera lens should be beyond the irradiation scope of useful beam(because of the dimness of lens under irradiation).Sockets for video information should be installed 2.5m from finished floor, and a cable conduit placed through the groove (reference the diagram a, P28) and towards the monitor on the consol table. Power sockets of 220V should be offered in the treatment room, just near the sockets for video at 2.5m from finished floor.

5.1.8.4 Talkback System (optional):

Sockets for microphone and buzzer should be installed 2 meters from finished floor, and a cable conduit for video wire be buried towards the fosse in the wall (reference to the diagram d,P28) with a video wire inside. The wire will be linked up to an amplifier on the consol table.

5.1.8.5 Emergency lights (optional see P31A-A):

A set of emergency lamps should be installed in the treatment room; another set should be installed in the labyrinths and consol area so that the patient can be moved away in case of emergency shutoff of power.

5.1.8.6 Shelves or cabinets for storage (prepared by customer)

Shinva Medical recommends that users produce corresponding indoor lockers (planes) for the storage accessories and other commonly used materials.

Accessories offered by **Shinva Medical**:

1 shelf for accessories (dimensions: diameter=480mm, height=175mm; maximum weight =3.8kg)

1 appendix bracket (dimension: diameter=475mm, height=110mm; maximum weight =3kg)

4 brackets for lead stopper (dimension: 300mm×300mm×6mm);

4 wedge filters (max dimension: 290mm×290mm×53mm/per; maximum weight =6.6kg)

13 (or 48) lead stopper (height=80mm ; maximum weight =3.5kg)

1 isocenter displaying system (maximum weight =4.8kg)

Other materials in common use:

Coverlid, gauze, chair, mirror, rack for clothes, pedal， waste bin, spare parts and servicing tools, plotting paper, marker for films, distilled water, dosimeter, flexible litter, film cabinet, cushions and brackets for location use, gauging tools such as plane ruler, all kinds canisters for irradiation shadow and suitable shaped lead blocks, dolly for holding the films, dolly for oxygen vase, platform for total-body radiotherapy.

5.1.8.7 Stand-socket

Several power sockets of 220V (see P28) should be installed 30cm from the finished floor in the treatment room， consol room and auxiliary room; they are used for future repair or other purposes. Two power sockets on each wall are preferred.

5.1.9 Fire facilities

Fire alarm is preferred here but not water extinguisher.

5.2 Control room

1. Control room should be as close as possible to the entrance to the treatment rooms, the best equipment Lade-window, with easy access and monitoring to prevent outsiders entered.
2. Recommendations in the control room to install direct dial telephone, to facilitate inspection accelerator Xinhua operating parameters and maintenance and troubleshooting guide.
3. The proposed allocation of the control room air-conditioners, dehumidifiers. To maintain the temperature at 20°C to 25°C, and the relative humidity is 30% -75%. Do not forget that for air conditioning pipe.
4. Pre-digging cable trenches, size finalized by the user. Console to the accelerator even for the internal standard cable length of 18 m.

5.3 Auxiliary Room

1. A constant temperature water chiller in the auxiliary room offers constant temperature water. The unit for the standard configuration of water-cooled. If water-cooling system chosen, two 5-meter long pipes of 20mm diameter are offered for the peripheral water-circulation system by Xinhua Medical. Special tap water pipe and sewer should be prepared in the auxiliary room, and a ZG3/4″ screwed nipple or a 90° elbow nipple is needed for the pipe nipples. Xinhua XHA600 Accelerator Unit of the water mains between the accelerator and the largest pipeline length of 25 m.
2. Ditch-digging cable (see Figure room layout plans Page19), the size of the final set by the user. A copper (or stainless steel) pipe of 1-inch diameter from the water chiller in the auxiliary room to the rear face of the accelerator should be buried in advance so that the inflow and outflow of constant temperature water can be guaranteed, U-shaped is preferred here(see P33). To minish the radiation, the lower part should be buried underground. Two copper (or stainless steel) pipes should be linked up with screw thread of ZG1″ at the ends, and global valve used in the treatment room, finally outer screwed nipple of ZG1″ or a 90° elbow screwed nipple (to link the outer screwed nipple of G1″ offered by Xinhua Medical) used in the linkage at the end of auxiliary room (see P34). The inner screw thread of ZG1″ should be left and sealed so that it can be easily linked with the special nipple of water/hose of 1–inch diameter in the installing process. Two black latex pipes of 6 meters are offered to the treatment room by Xinhua Medical, and two 1″ hoses of 6 meters to the auxiliary room. The customer should take responsibility to reset the pipes at the places where water pipes available with elbows and stainless steel pipe. In order to keep the cleanness of the inner side of the pipes, clean parts such as pipes and valves are used in the installation。 The position and direction of the nipple should be convenient to link in the water pipe of the accelerator.
3. Auxiliary room dedicated to a water faucet and the leaking, the leak must be at the lowest point, in order to ensure full and timely water discharge.
4. Power distribution disk accelerator installed in the auxiliary engine room and the control room wall, it is perpendicular to the cables through walls through the ditch.

Chapter.6 Packing list

Case No.	Dimensions (cm)	Gross weight (kg)	Net weight (kg)	Main components
1	298x164x240	4568	4183	Main body, booster, toolbox
2	228x150x160	317	87	Fiberglass cover, rear cover of gantry, gantry top
3	264x68x100	257	158	Couch frame, couch axis. Couch faceplate, frontal cover, side door, and laser positioning lights. Emergency switches, door switch, door gemel
4	168x78x93	977	893	Couch body
5	119.5x126x50	970	717	Couch base. Joint fastener. Staff gauge
6	142x72x99	2052	1977	Counter weight
7	140x83x101	210	154	Modulator
8	90x68x98	162	116	Console
9	107x63x87			Brackets for accessories, appendix brackets, magnetron, wedges.CX1159.5C22grid glow tube, bracket (drilled or not) for lead stopper
10	Optional parts	320	270	Power regulator
11	142x125x132	362	285	Computer, monitor, interphones, emergency switches
12	Optional parts			Constant temperature water system
13		800	660	Linac base

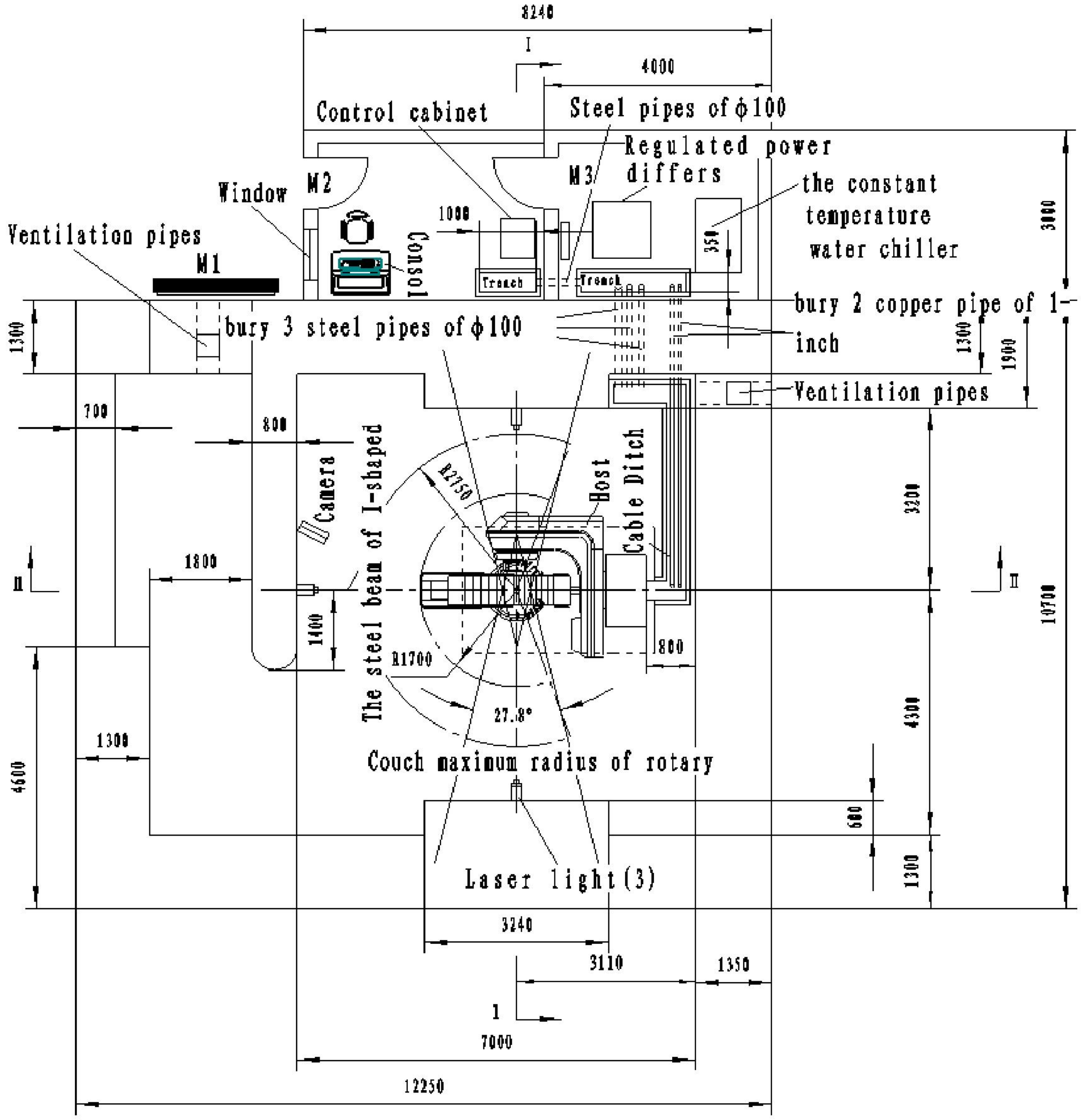
Remark: If the type of the constant temperature chiller and regulated power differs, the dimension and weight of each will vary correspondingly.

Chapter.7 Appendix

1. IEC Medical Electrical Equipment. Part 2: Particular requirements for safety of medical electron accelerators in the range 1 MeV to 50 MeV. Publication 601-2-1 Section five: Radiation requirements.
2. IEC Report, IEC977, Medical Electron Accelerators. Guidelines for functional performance characteristics, 1989.
3. IEC Report, IEC976, Medical Electron Equipment. Medical electron accelerators-Functional performance characteristics, 1989.
4. NCPP Report No.39: *Basic radiation protection criteria*, National Council on Radiation Protection and Measurements, Bethesda, MD, 1979, p145.
5. NCPP Report No.49: *Structural shielding design and evaluation for medical use of x-rays and gamma rays of energies up to 10 MeV*, National Council on Radiation Protection and Measurements, Bethesda, MD, 1976, p126.
6. NCPP Report No.51: *Radiation protection design guidelines for 01-100 MeV particle accelerator facilities,* National Council on Radiation Protection and Measurements, Bethesda, MD, 1977, p159.
7. NCPP Report No.88: *Radiation alarms and access control systems.* National Council on Radiation Protection and Measurements, Bethesda, MD, 1986, p81.
8. DeSTAEBLER, H., JENKINS, T.M.., NELSON, W.R., "shielding and radiation", the Standard Two-Mile Accelerator (NEAL, R.B., Ed), Ch.26, Benjamin, NEW York (1968).
9. ICRP Publication 73.Radiological protection and safety in medicine, International Commission on Radiological Protection. Pergamon, Oxford, 1996.

Chapter.8 Appendix figure

Figure 1:



1. Ditch size: width350; depth480
2. Ditch over platform: width490; depth30
3. Stand and the back wall minimum range is 0.7m

Figure2

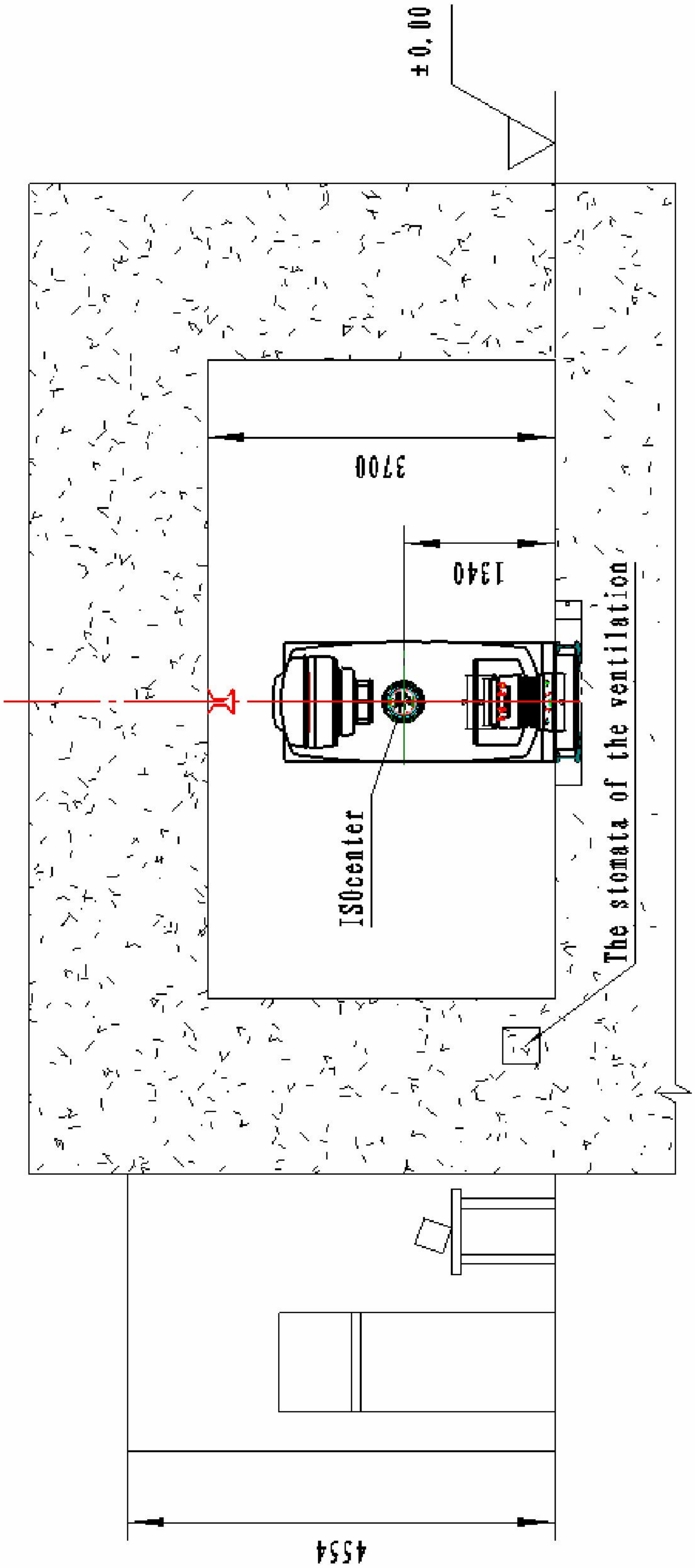

±0.00
3700
1340
ISOcenter
The stomata of the ventilation
4554

Figure3

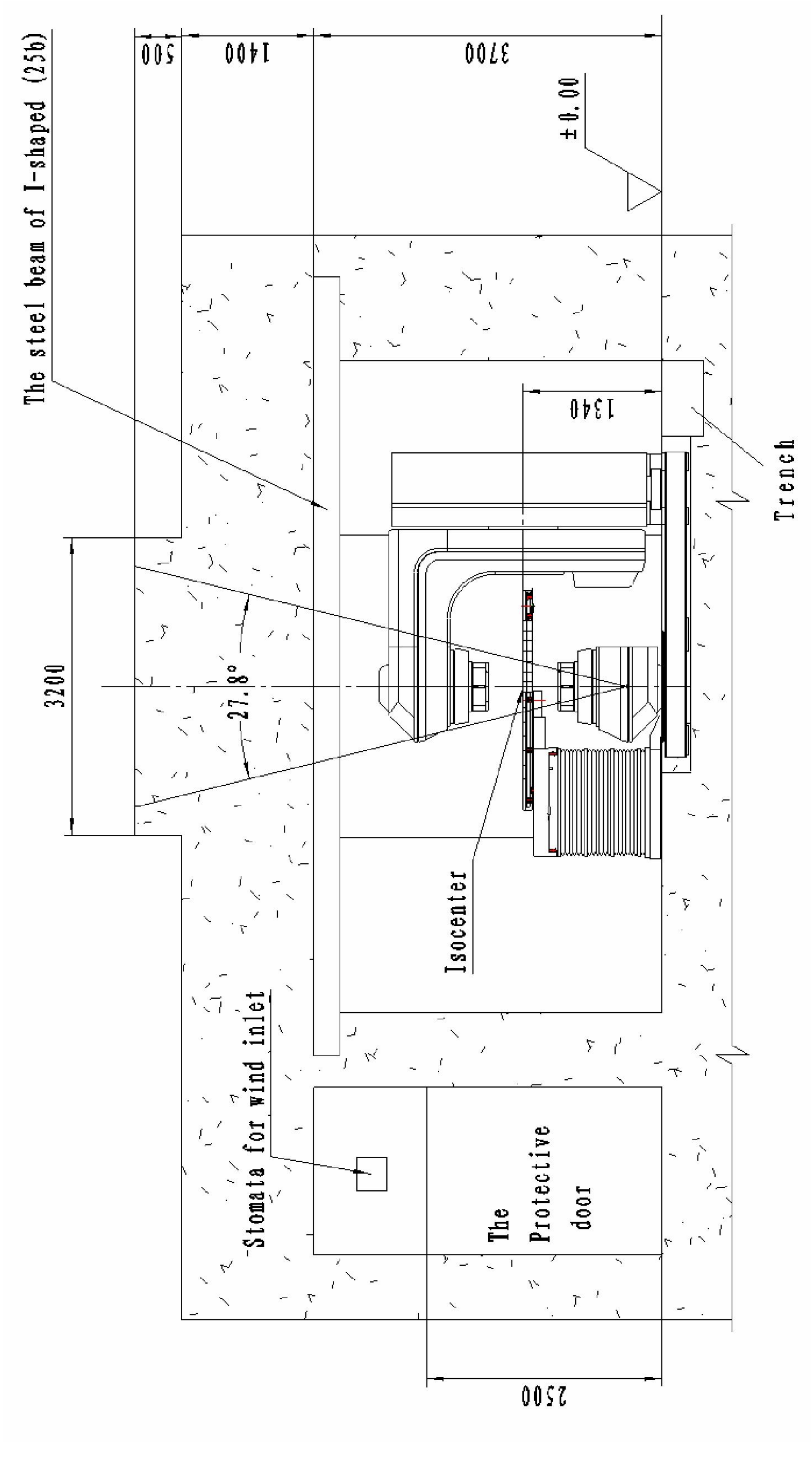
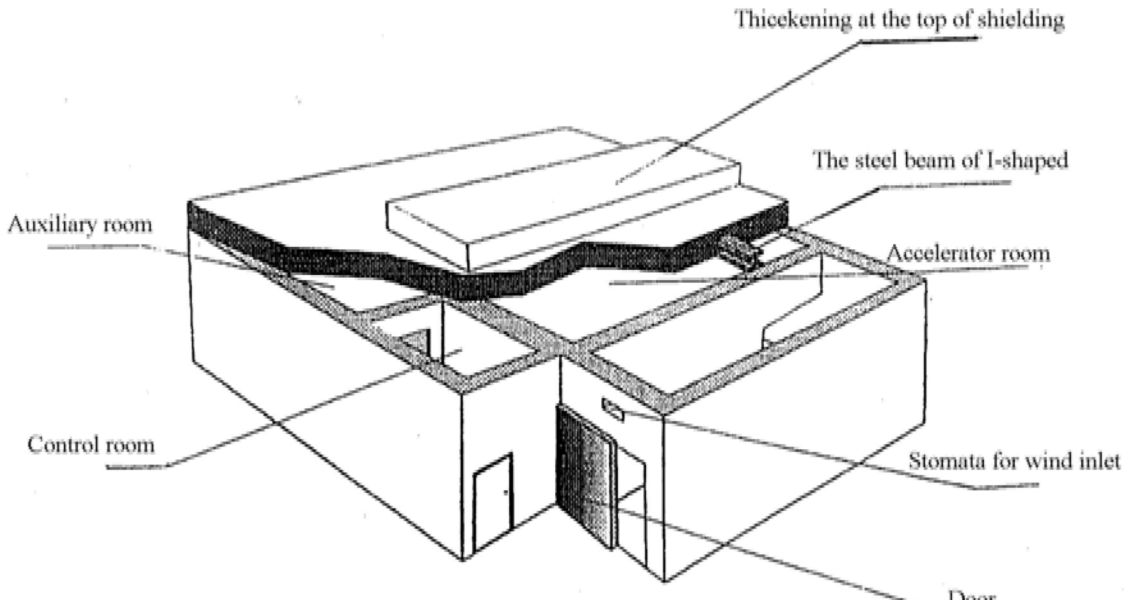
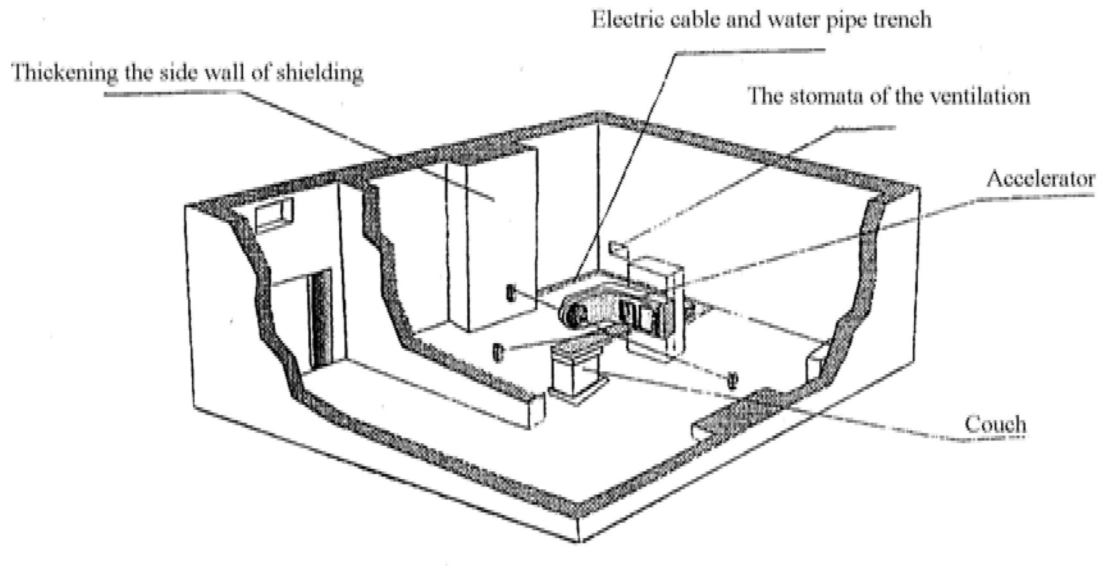

The steel beam of I-shaped (25b)
500
1400
3700
±0.00
1340
Trench
3200
27.8°
Isocenter
Stomata for wind inlet
The
Protective
door
2500

Figure4

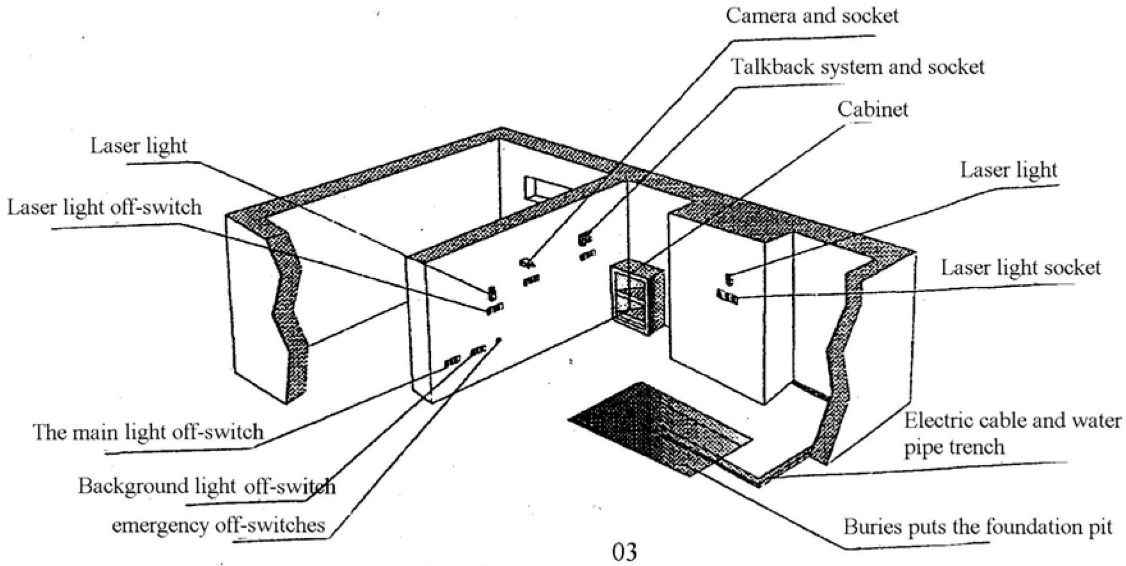


01

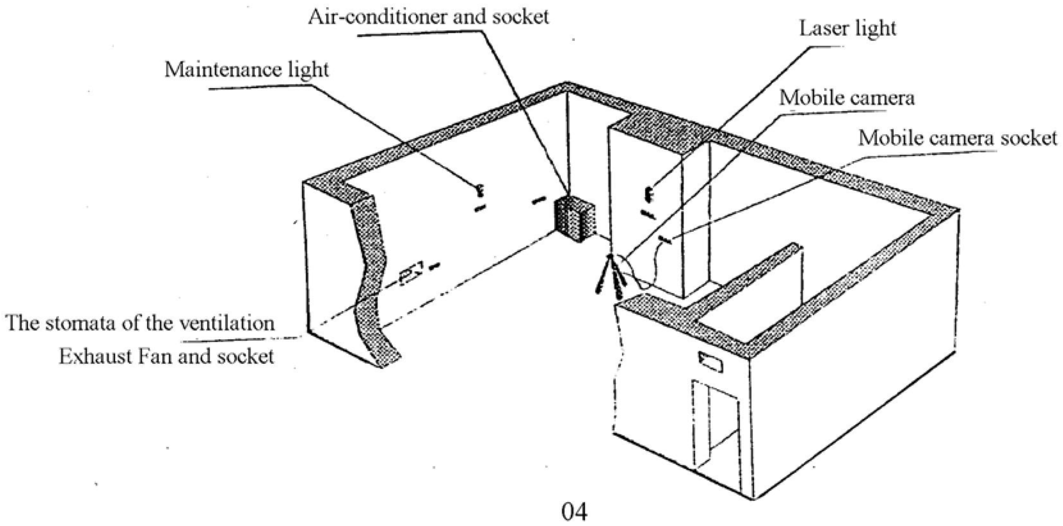


02

Figure5



03



04

Figure6

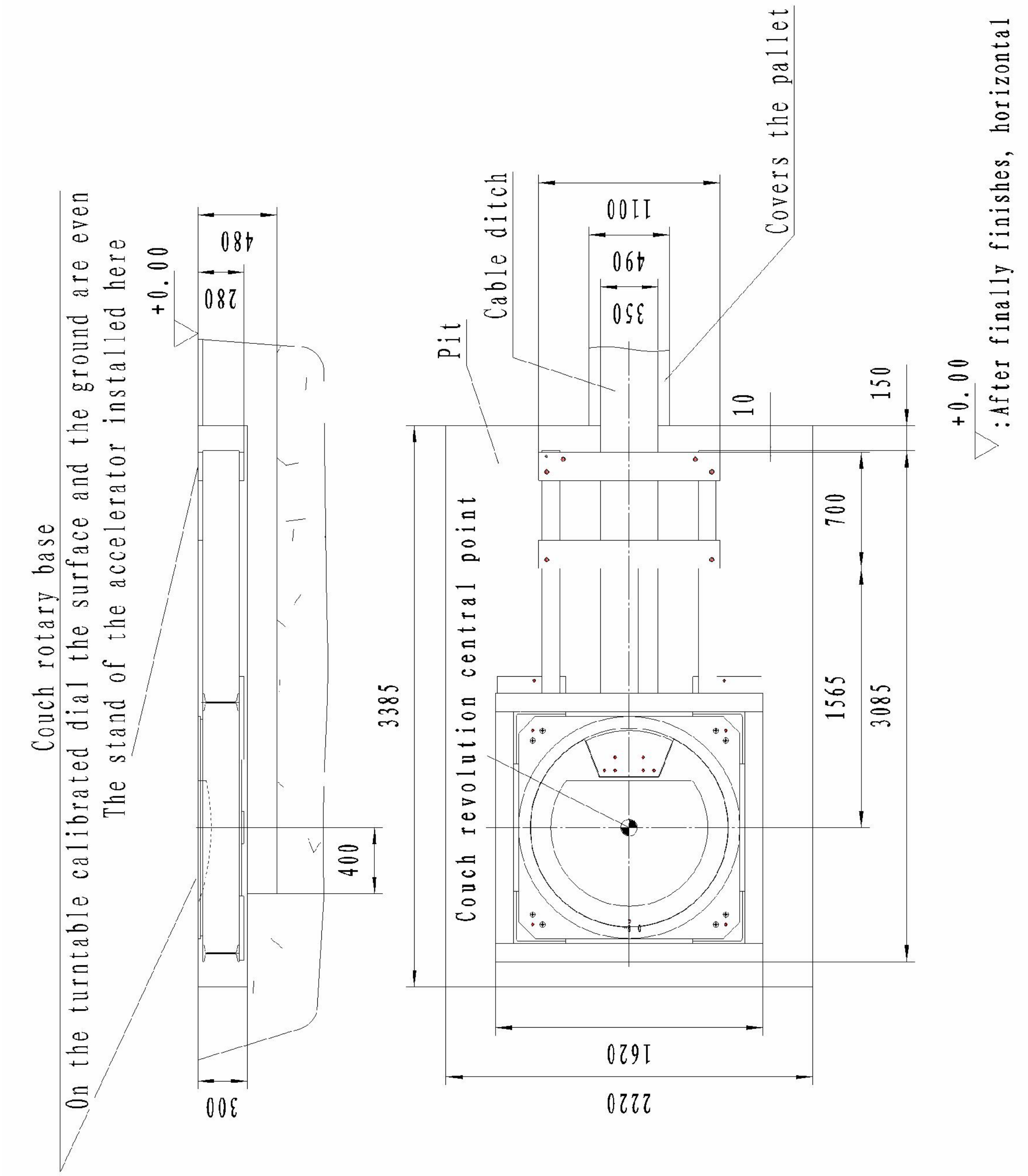

Couch rotary base
On the turntable calibrated dial the surface and the ground are even
The stand of the accelerator installed here
+0.00
480
280
300
400
Pit
Cable ditch
Covers the pallet
1100
490
350
10
150
+0.00
: After finally finishes, horizontal
700
1565
3085
3385
Couch revolution central point
1620
2220

Figure7

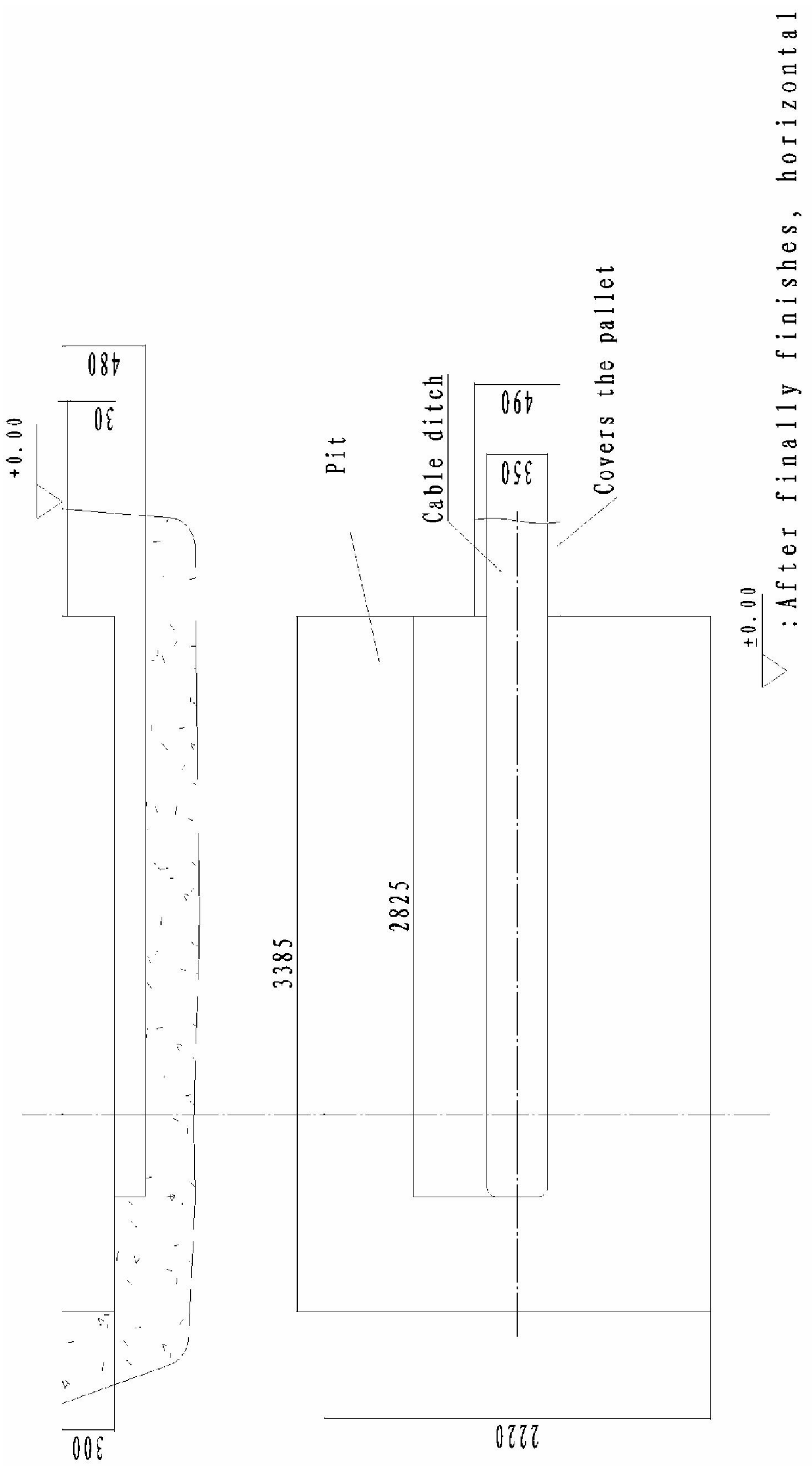

+0.00
480
30
Pit
Cable ditch
490
350
Covers the pallet
±0.00 : After finally finishes, horizontal
3385
2825
300
2220

Figure8

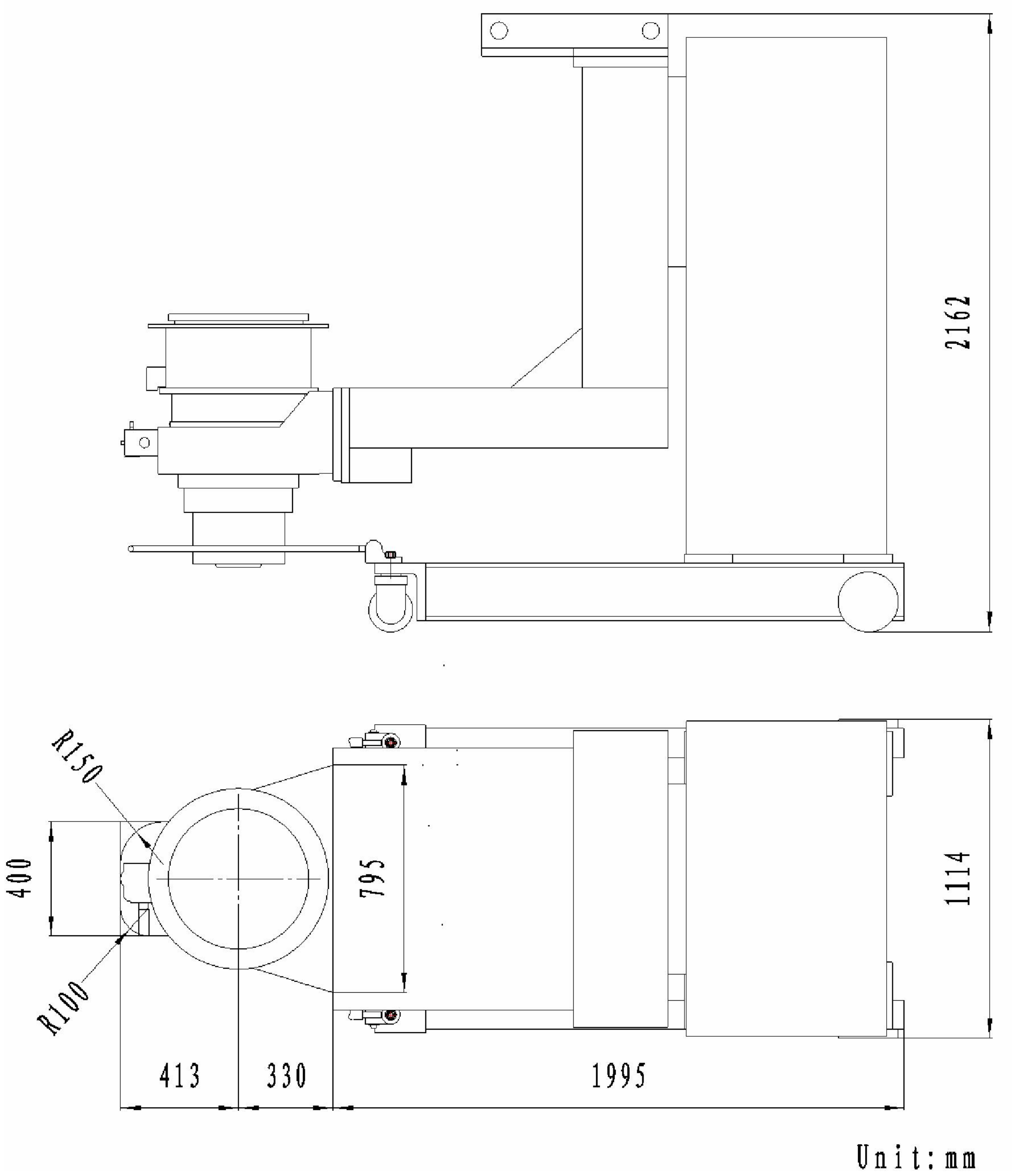
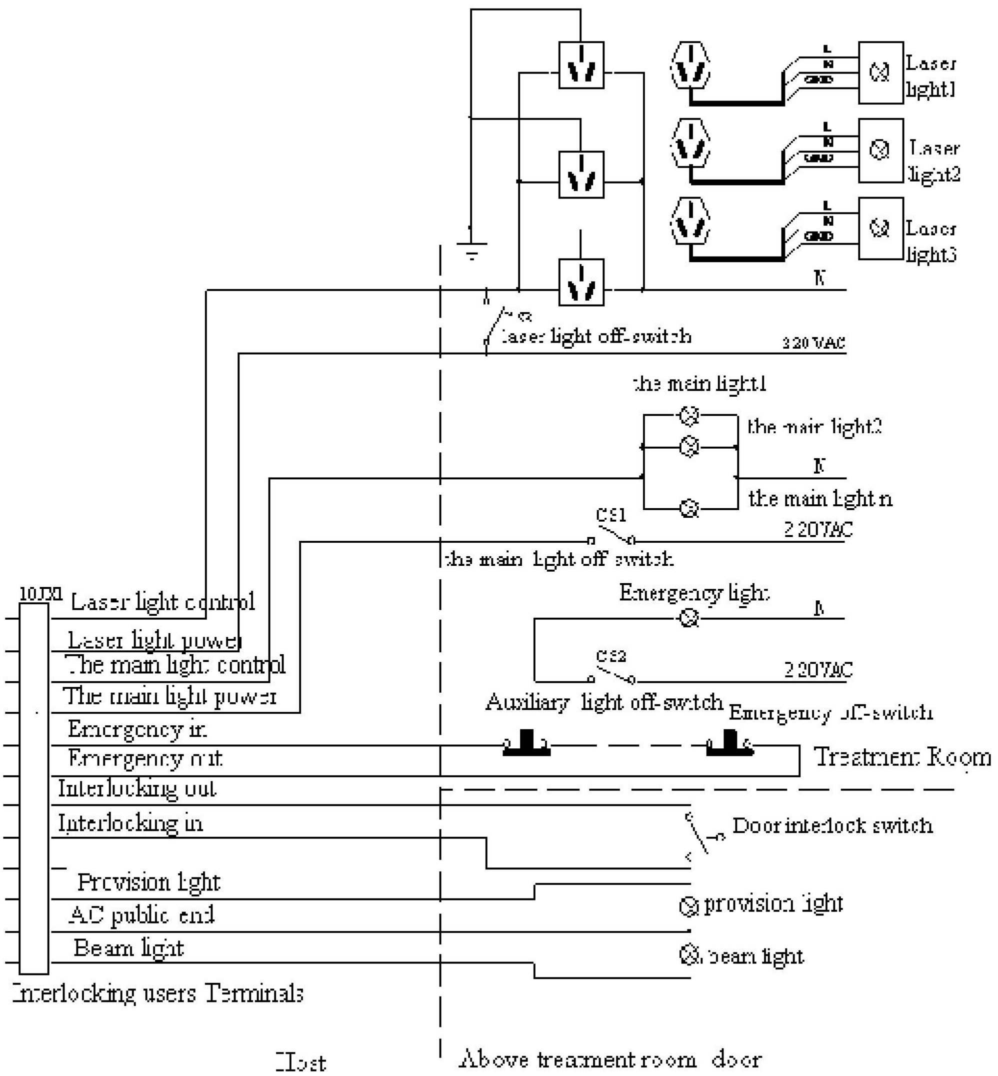


Figure9



Explanation

1. before the accelerator main engine installs, the user must unite 11 the dotted line to meet to the main engine underneath in the cable trench reservation length three meters.

2. The main lights, auxiliary lights, a light beam, ready to light, the door interlock switch, switch lights, laser lights switch installed by the user, the manufacturers to provide users with an exigency stop switch, installed by the user, if Users need to increase the exigency stop switch, to be all exigency stop the use of tandem switches.

3. Interlocking line the main lights in the short accelerator installed before then, so that the main lights to normal use.

4. Laser lights from the manufacturer to install the accelerator after the completion of the installation.

5. Beam light use of 220 V yellow warning light,Ready light use of 220 V green light to indicator.

6. Laser lights can be switched control of the treatment room walls, but also by the accelerator control.

7. The main lights switch control from the wall, when I put out by the accelerator control. Auxiliary lights in the main lights off when the use of background light.

Figure10

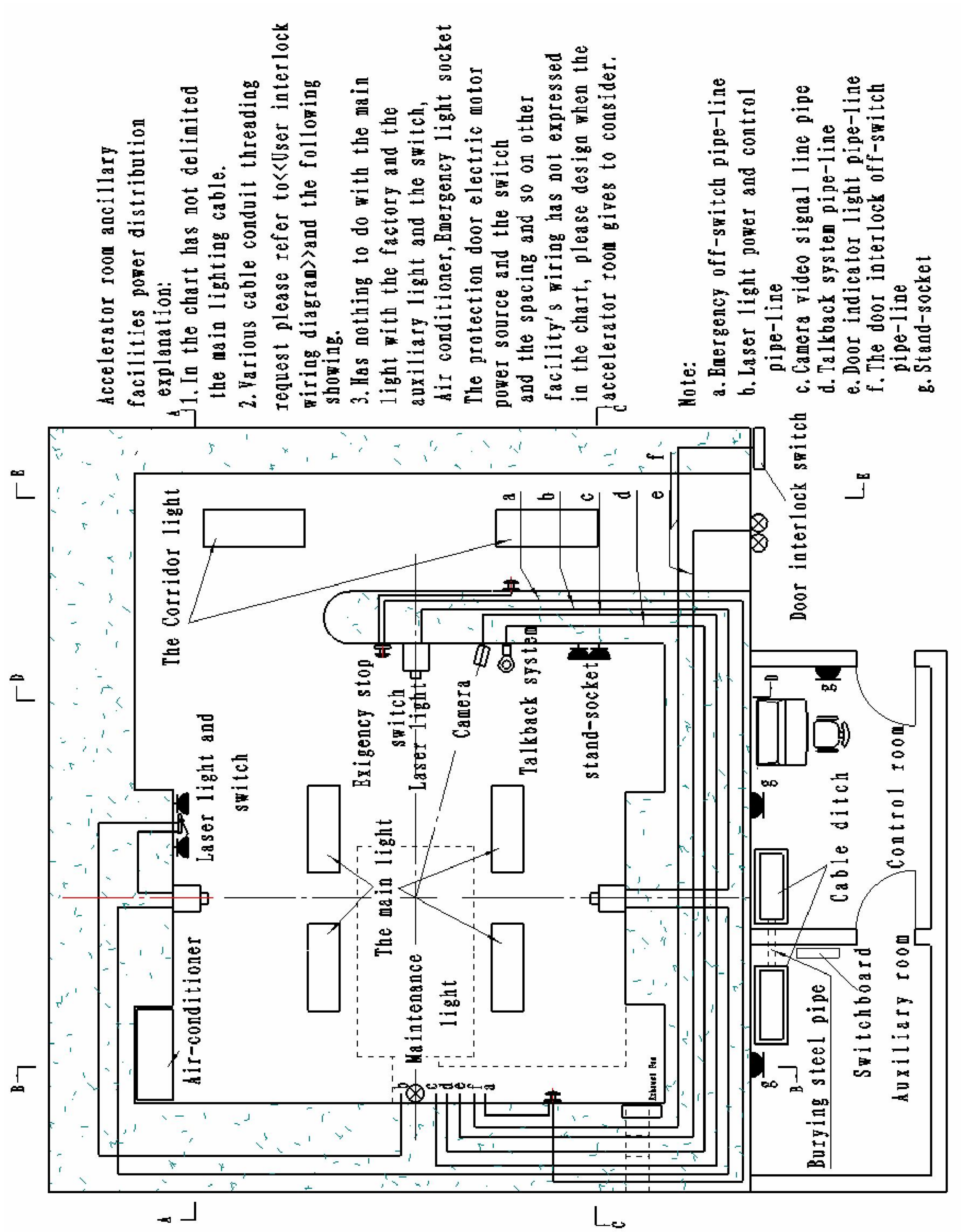
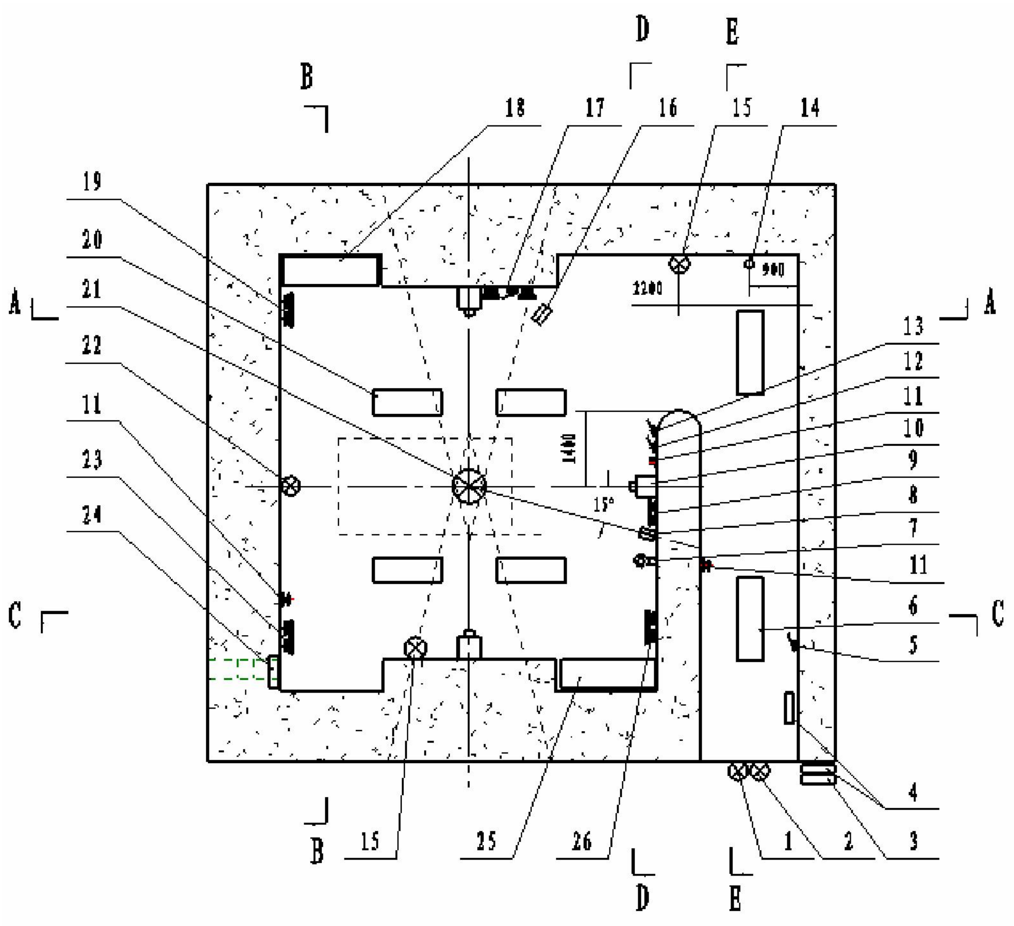

Accelerator room ancillary facilities power distribution explanation:
1.In the chart has not delimited the main lighting cable.
2.Various cable conduit threading request please refer to<<User interlock wiring diagram>>and the following showing.
3.Has nothing to do with the main light with the factory and the auxiliary light and the switch, Air conditioner,Emergency light socket The protection door electric motor power source and the switch and the spacing and so on other facility's wiring has not expressed in the chart, please design when the accelerator room gives to consider.
Note:
a.Emergency off-switch pipe-line
b.Laser light power and control pipe-line
c.Camera video signal line pipe
d.Talkback system pipe-line
e.Door indicator light pipe-line
f.The door interlock off-switch pipe-line
g.Stand-socket
The Corridor light
Laser light and switch
Air-conditioner
Exigency stop switch
Laser light
Camera
Talkback system
stand-socket
The main light
Maintenance light
Door interlock switch
Control room
Cable ditch
Switchboard
Burying steel pipe
Auxiliary room

Figure11



NO.	Name	NO.	Name
13	The main light off-switch	26	Stand-socket
12	Background light off-switch	25	Cabinet
11	Emergency off-switch	24	Exhaust Fan
10	Laser light(With socket)	23	Exhaust Fan socket and stand-socket
9	Dehumidifier and socket	22	Maintenance light(with socket)
8	Camera(with socket and stand-socket)	21	Background light
7	Talkback system and socket	20	The main light
6	The Corridor light	19	Air-conditioner socket
5	The Corridor light off-switch	18	Air-conditioner
4	Door off-switch	17	Mobile camera socket and switch
3	Door interlock off-switch	16	Mobile camera
2	Beam warning light	15	Emergency lights
1	Provision light	14	Suspension link

Figure12

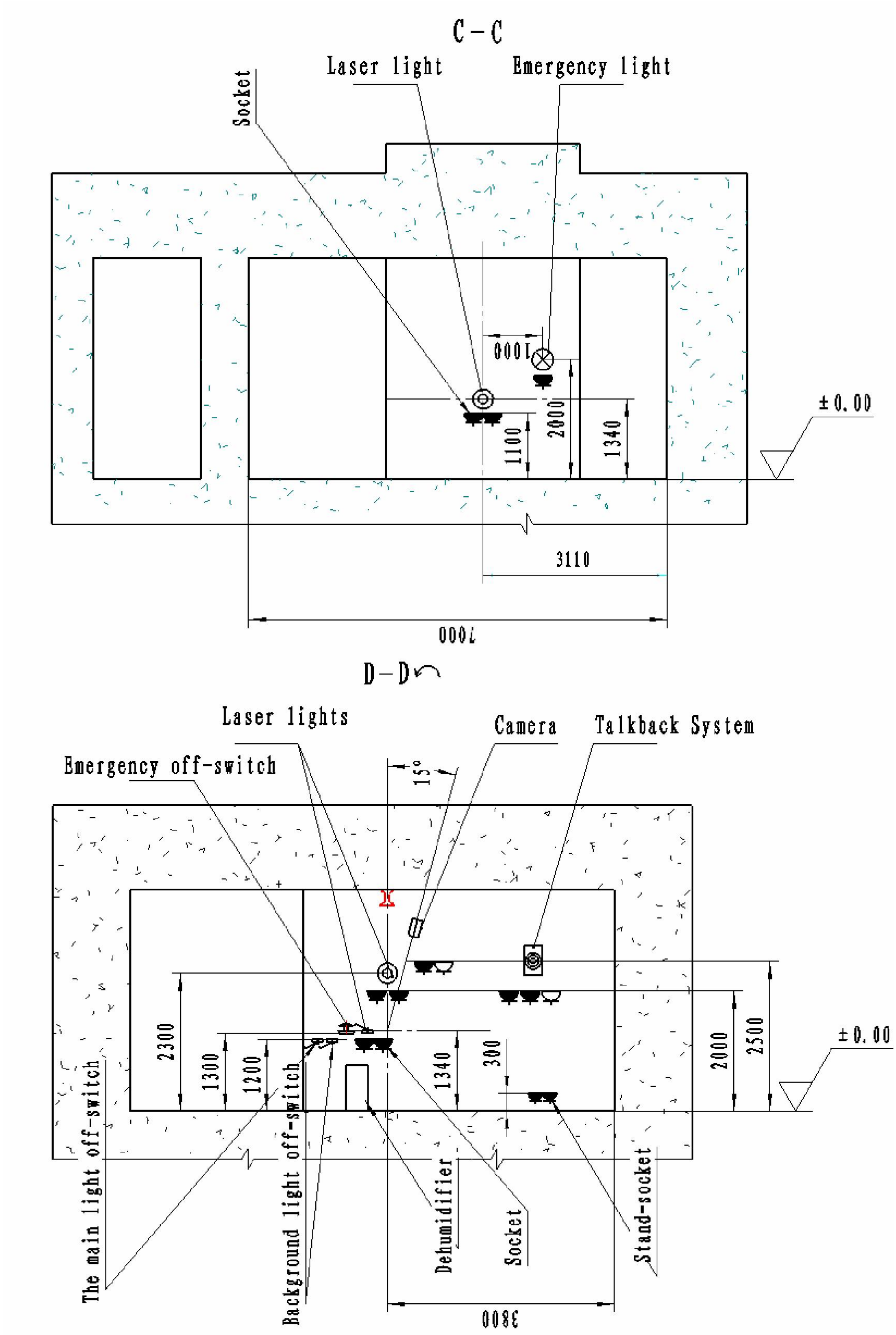

C-C
Laser light
Emergency light
Socket
1000
±0.00
1100
2000
1340
3110
7000
D-D
Laser lights
Camera
Talkback System
Emergency off-switch
15°
2300
1300
1200
1340
300
2000
2500
±0.00
The main light off-switch
Background light off-switch
Dehumidifier
Socket
Stand-socket
3800

Figure13

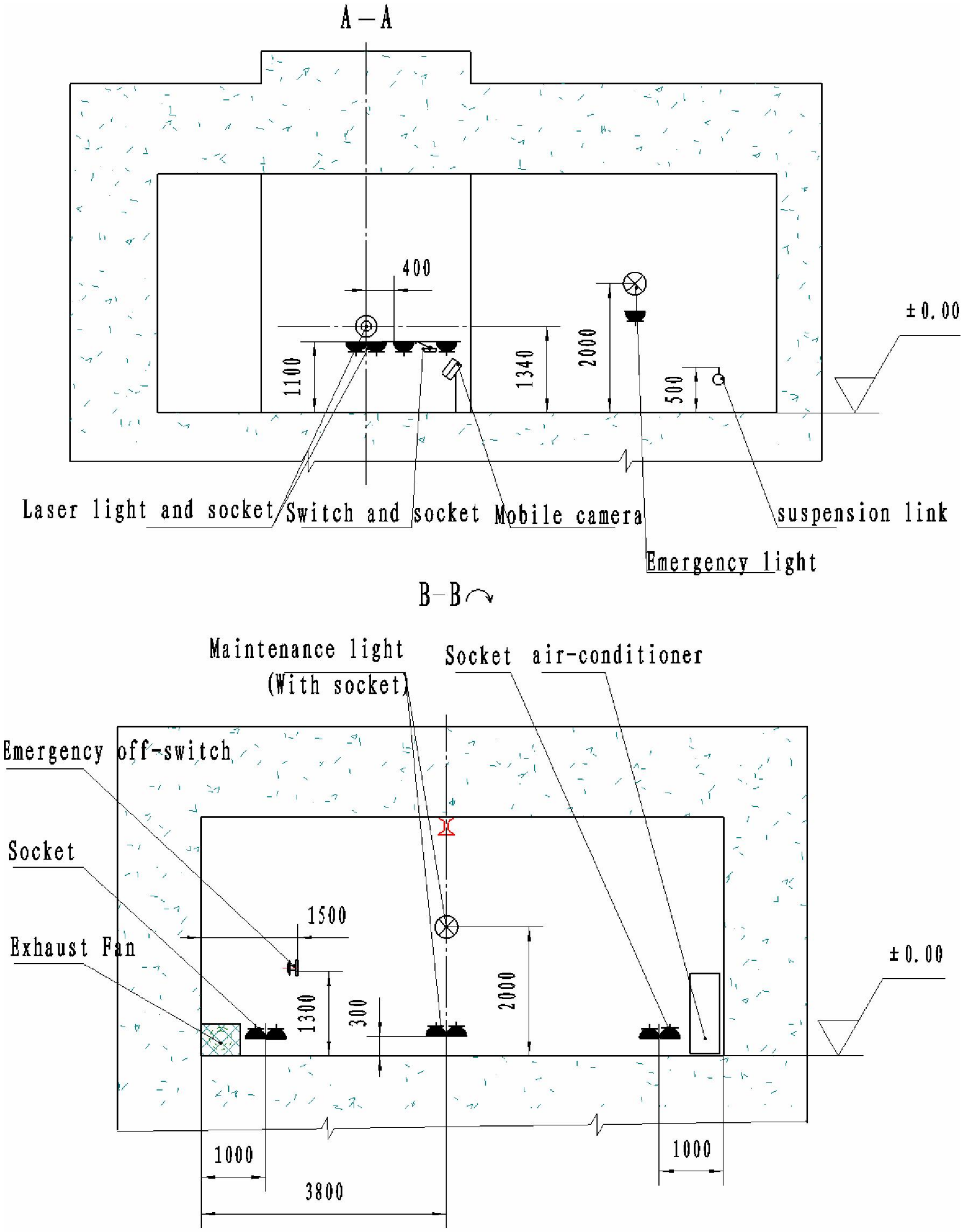

A－A
400
1100
1340
2000
500
±0.00
Laser light and socket
Switch and socket
Mobile camera
suspension link
Emergency light
B-B
Maintenance light
(With socket)
Socket
air-conditioner
Emergency off-switch
Socket
Exhaust Fan
1500
1300
300
2000
±0.00
1000
3800
1000

Figure14

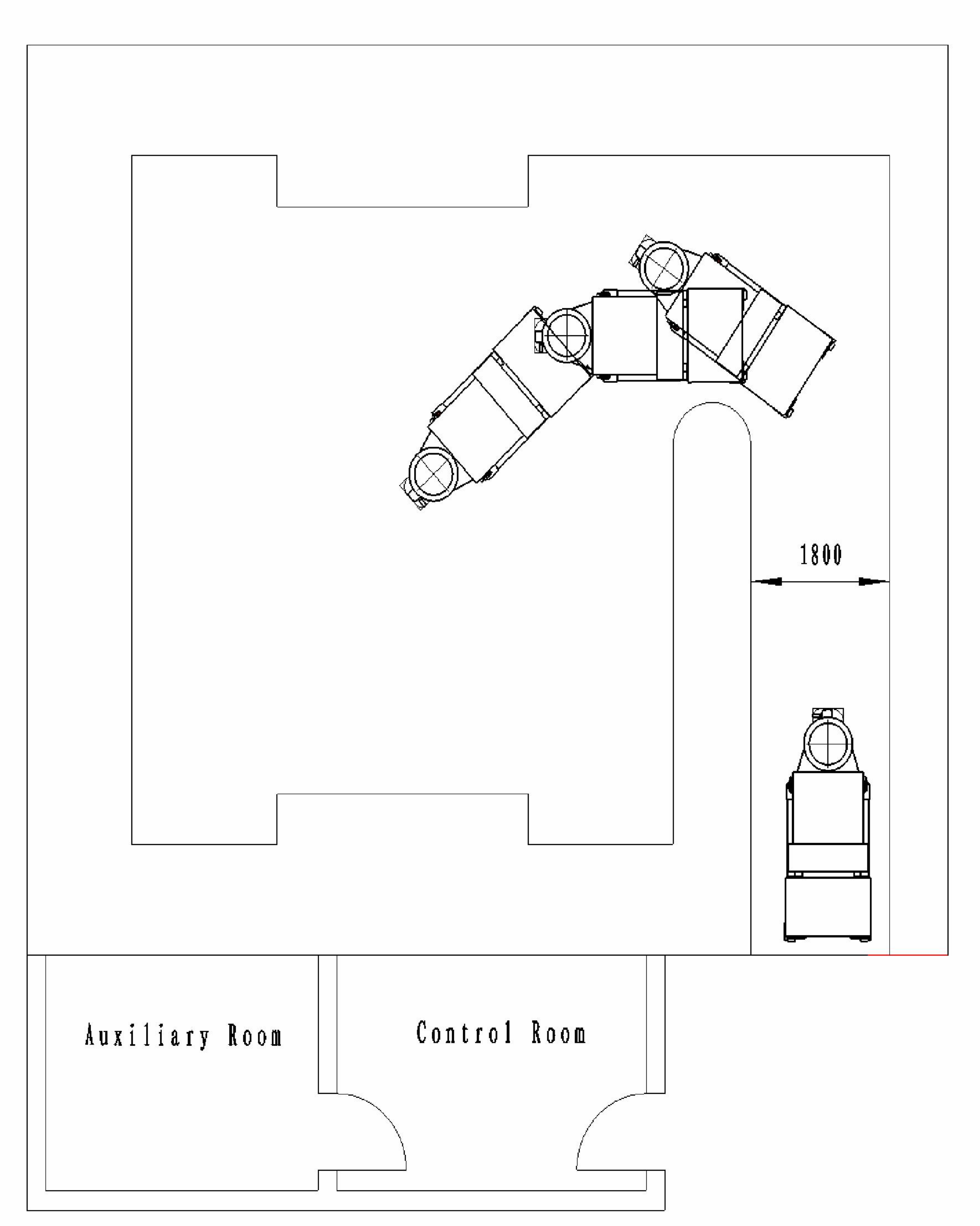


Figure15

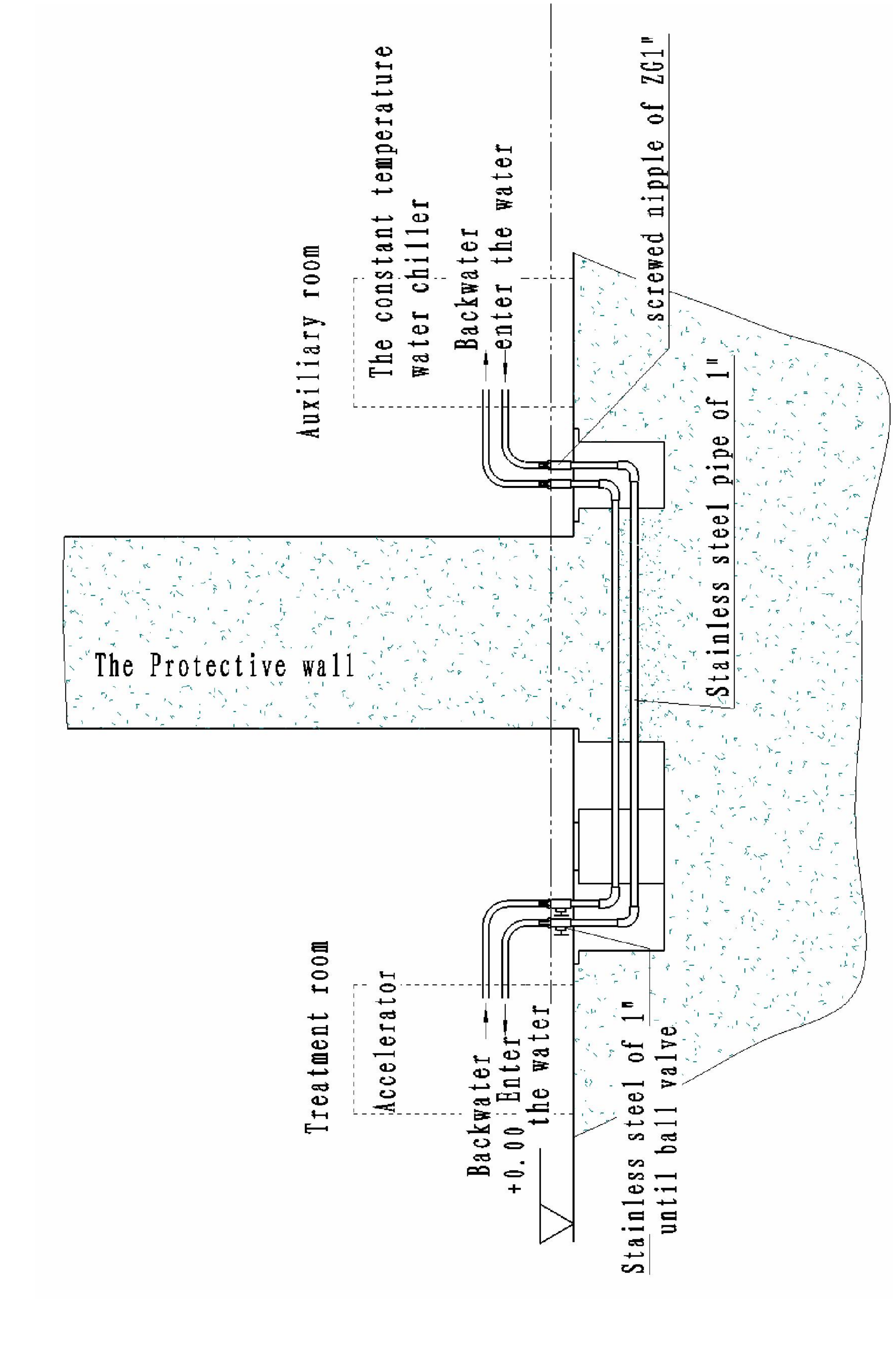
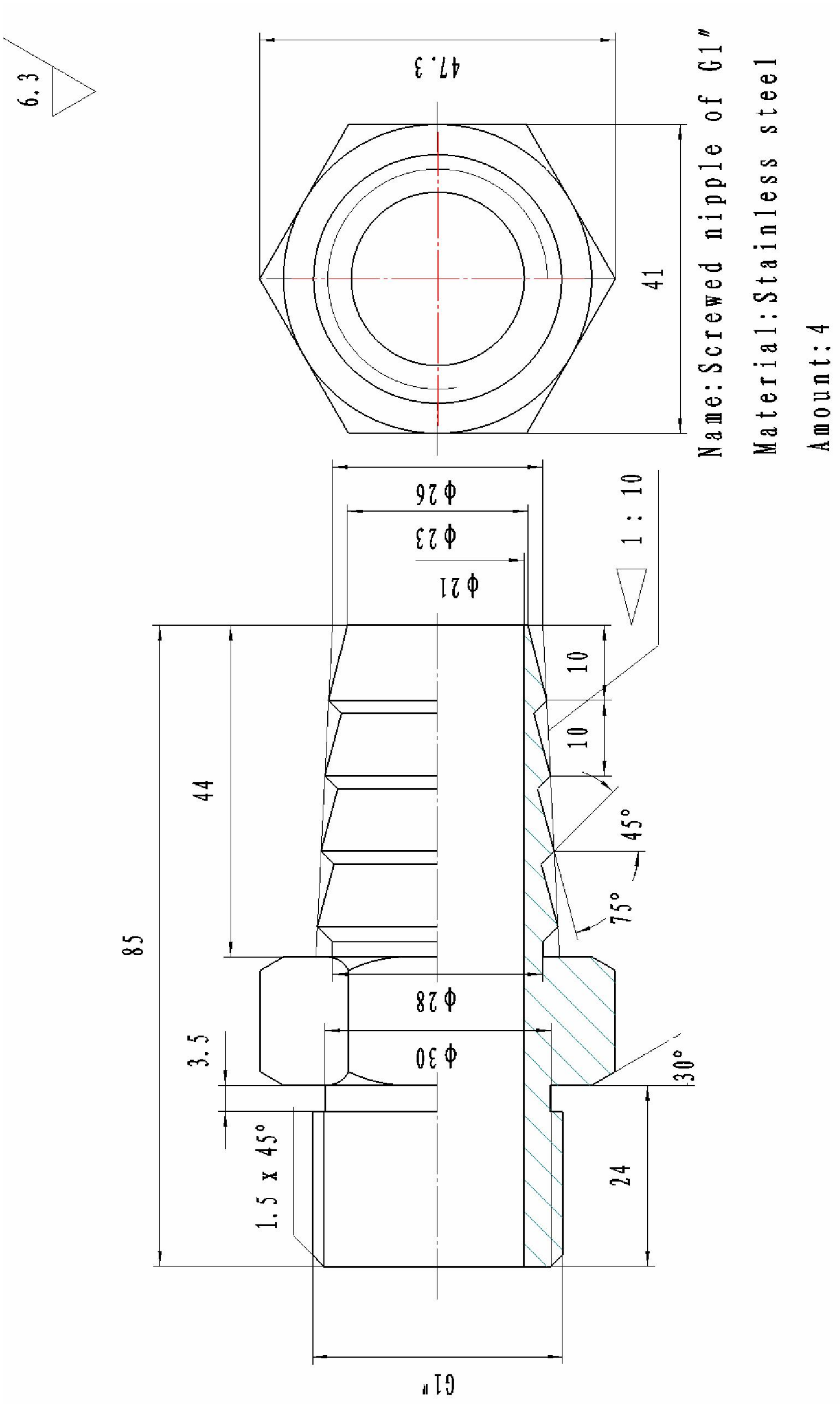
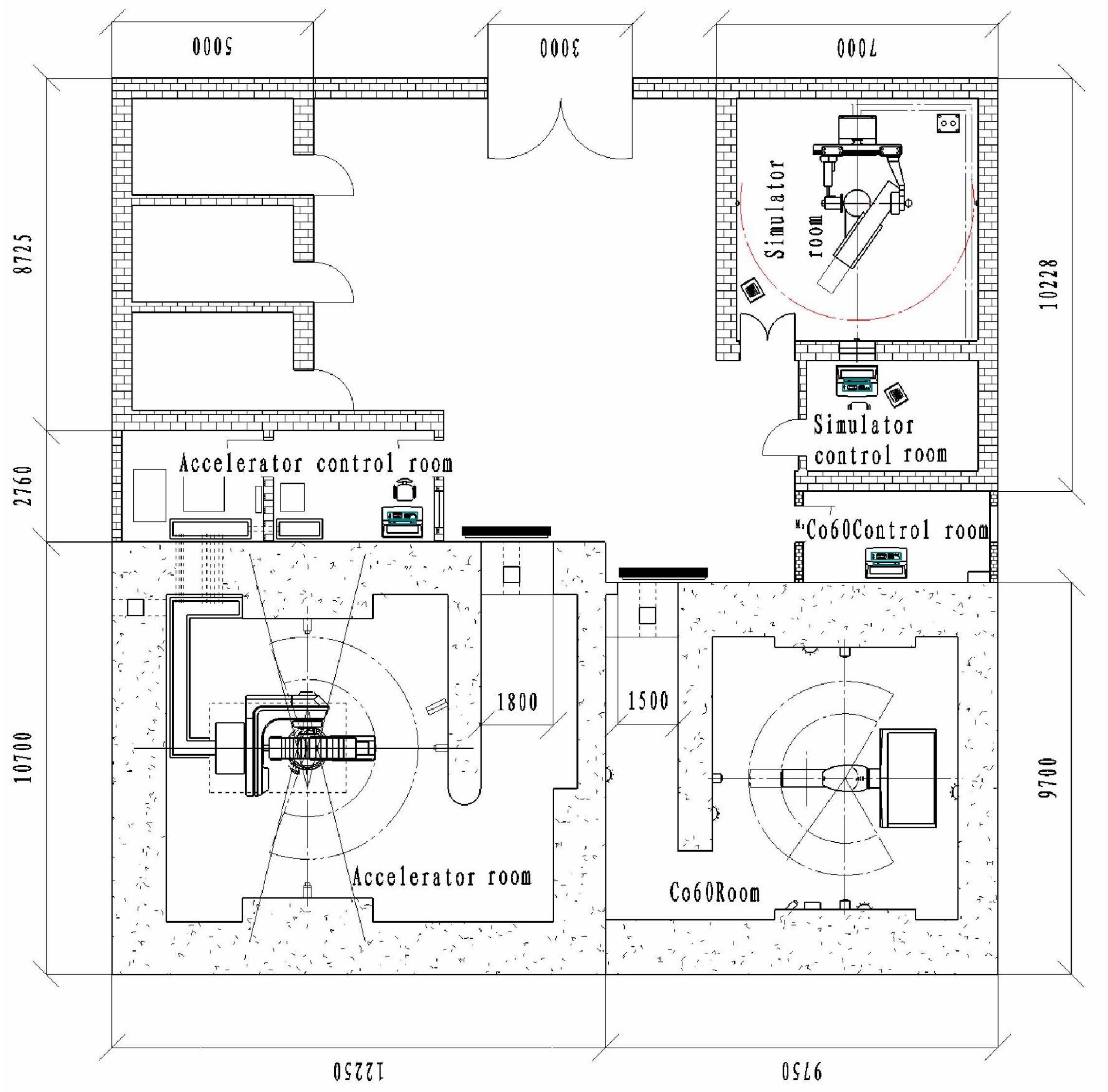

Auxiliary room
The constant temperature
water chiller
Backwater
enter the water
screwed nipple of ZG1"
Stainless steel pipe of 1"
The Protective wall
Treatment room
Accelerator
Backwater
Enter
the water
+0.00
Stainless steel of 1"
until ball valve

Figure16



Name:Screwed nipple of G1"
Material:Stainless steel
Amount:4
6.3
47.3
41
Φ26
Φ23
Φ21
1 : 10
10
10
45°
75°
44
85
Φ28
Φ30
3.5
30°
1.5 x 45°
24
G1"

Figure17


5000
3000
7000
8725
2760
10700
10228
9700
12250
9750
Simulator room
Simulator control room
Accelerator control room
Co60Control room
1800
1500
Accelerator room
Co60Room

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