PROJECT	ПРОЕКТ
SHELTER IMPLEMENTATION PLAN (SIP) NEW SAFE CONFINEMENT DESIGN, CONSTRUCTION AND COMMISSIONING CONTRACT N° SIP08-1-001	**ПЛАН ОСУЩЕСТВЛЕНИЯ МЕРОПРИЯТИЙ (ПОМ) НОВЫЙ БЕЗОПАСНЫЙ КОНФАЙНМЕНТ КОНТРАКТ НА ПРОЕКТИРОВАНИЕ, СТРОИТЕЛЬСТВО И ВВОД В ЭКСПЛУАТАЦИЮ № SIP08-1-001**
EMPLOYER	ЗАКАЗЧИК
THE STATE SPECIALIZED ENTERPRISE "CHERNOBYL NPP"	ГОСУДАРСТВЕННОЕ СПЕЦИАЛИЗИРОВАННОЕ ПРЕДПРИЯТИЕ "ЧЕРНОБЫЛЬСКАЯ АЭС"
ENGINEER	ИНЖЕНЕР
THE PROJECT MANAGEMENT UNIT (PMU)	**ГРУППА УПРАВЛЕНИЯ ПРОЕКТОМ (ГУП)**
CONTRACTOR	ПОДРЯДЧИК
NOVARKA, a Joint Venture made of : VINCI Construction Grands Projets (VCGP, leader) and Bouygues Travaux Publics (ByTP, member)	Совместное предприятие NOVARKA в составе: VINCI Construction Grands Projets (VCGP-ведущая фирма) и Bouygues Travaux Publics (ByTP - участник)

. . . Putting Technology To Work

Project Name			Originator	Sub-division		SIP Task		Task Breakdown Code				Type of Document			Serial Number			Revision	
Наименование проекта			Автор	автор или подразделение		Задача ПОМ		Шифр позадачной разбивки				Тип документа			Серийный номер документа			Редакция	
S	I	P	N	L	I	2	2	A	5	0	0	C	D	S	0	0	1	0	1

Systems, Structures & Components Important to Safety	Systems, Structures & Components Not Important to Safety	Системы, конструкции, и компоненты, важные для безопасности	Системы, конструкции, и компоненты, не важные для безопасности

DOCUMENT TITLE	НАЗВАНИЕ ДОКУМЕНТА
NSC CS-1 CONCEPT DESIGN SAFETY DOCUMENT APPENDIX FOR INFORMATION: NSC CS-1 CONTRACTOR'S PROPOSAL ON THE NSC CS-1 - TECHNICAL CONCEPT	**ДОКУМЕНТ ПО БЕЗОПАСНОСТИ В РАМКАХ КОНЦЕПЦИИ ПРОЕКТА ПК-1 НБК** ПРИЛОЖЕНИЕ ДЛЯ ИНФОРМАЦИИ: ПРЕДЛОЖЕНИЯ ПОДРЯДЧИКА ПК-1 НБК ПО ТЕХНИЧЕСКОЙ КОНЦЕПЦИИ ПК-1 НБК

ENGLISH VERSION	~~RUSSIAN VERSION~~	АНГЛИЙСКАЯ ВЕРСИЯ	~~РУССКАЯ ВЕРСИЯ~~

01	2008-12-04	SPO / NSH	PMI	INF		MHR
00	2008-07-04	GMA	PMI	PRE	First issue	MHR
Rev. Ред.	Date Дата	Prepared Подготовил	Checked Проверил	Status Статус	Reason for Revision Причины изменения	Approved Утвердил

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A1 STEEL ARCH

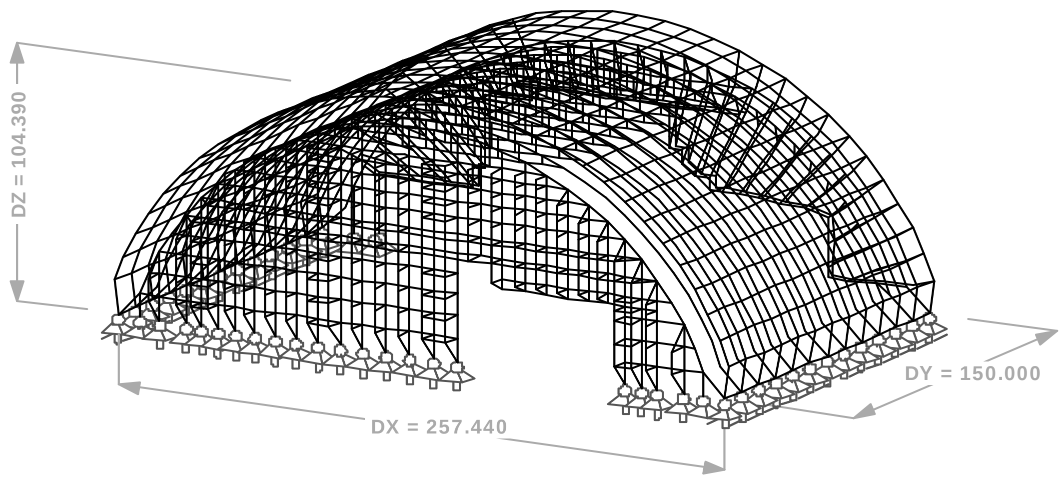


Figure A1. 3D Model of the Arch

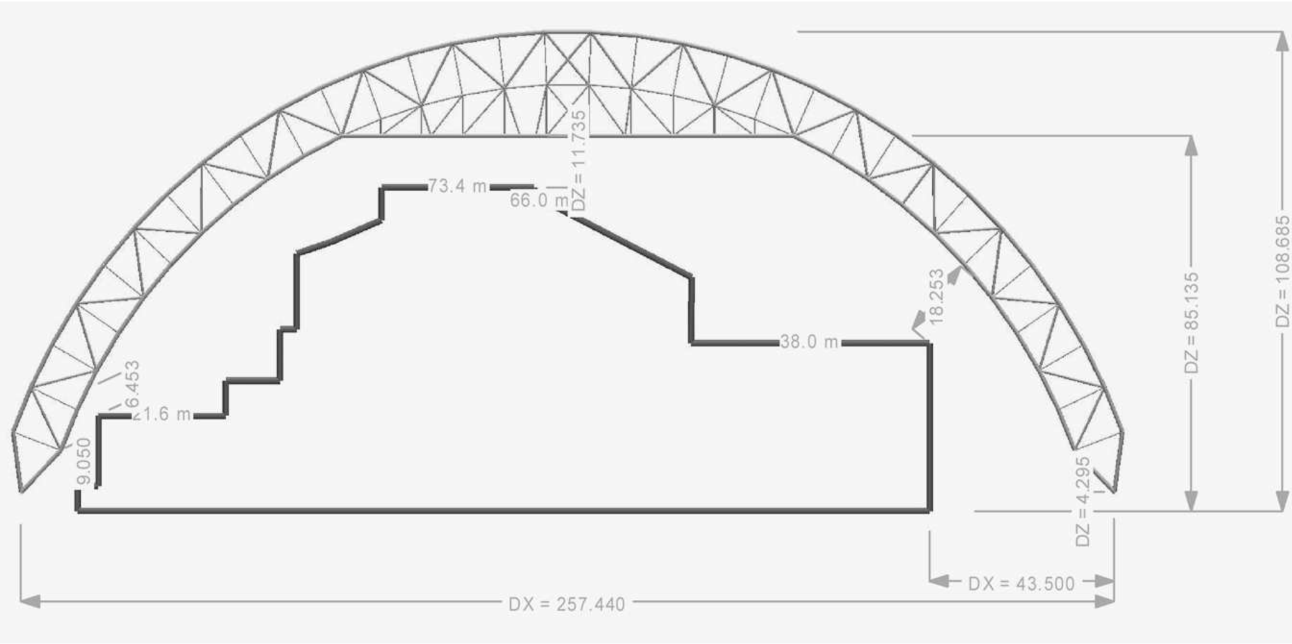


Figure A2. Main dimensions of the Arch

The overall dimensions of the NSC steel arch are shown in the figures above: maximum height 103.390 m, length in the east-west direction: 150 m and width in the north-south direction: 257.440 m

The main bearing structure of the NSC consists of 13 steel arches spaced at 12.5 m interval. A 14th and 15th arches have been added on the west and east walls to ensure the structural continuity.
Due to the erection method, the central arch will be also be doubled.

The 16 steel arches consist of a lattice structure with circular tubes interconnected longitudinally by horizontal infill beams and bracings. The lattice arches are made of an inner and an outer chord connected through orthogonal and diagonal bracings.

At the two arch-ends, both chords converge at the midpoint to form the arch base together with symmetrically arranged vertical bracings and a horizontal circular hollow beam connecting the arches.

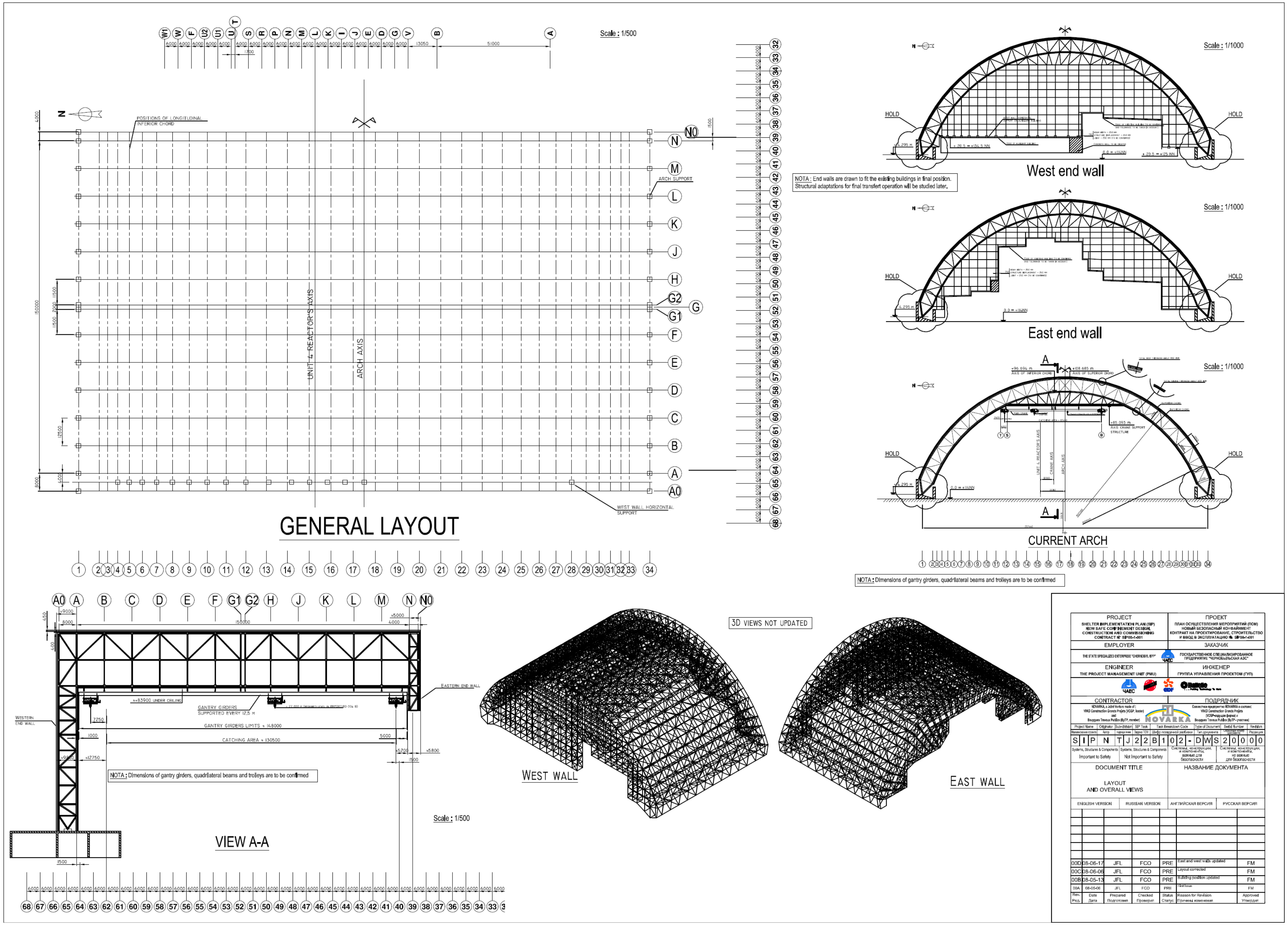
A horizontal lattice beam plan is arranged at +85.093m to support the travelling crane structure.

The upper chord supports the purlins carrying the roofing and the lower chord supports the ceiling. The inner space between the roofing and the ceiling is a closed annular space protecting the steel structure.

The steel members will be assembled by high strength friction bolts for site connections.

The followings drawings of the arch are in the next pages:

- SIP-N-TJ-22B102-DWS-200-Rev 0D _ Layout and overall views
- SIP-N-TE-22B102-DWG-001-Rev 00 _ Main Crane – Catching Area



GENERAL LAYOUT
Scale : 1/500
UNIT 4 REACTOR'S AXIS
ARCH AXIS
West end wall
East end wall
CURRENT ARCH
Scale : 1/1000
HOLD
NOTA : End walls are drawn to fit the existing buildings in final position. Structural adaptations for final transfert operation will be studied later.
NOTA : Dimensions of gantry girders, quadrilateral beams and trolleys are to be confirmed
VIEW A-A
3D VIEWS NOT UPDATED
WEST WALL
EAST WALL
DOCUMENT TITLE
LAYOUT AND OVERALL VIEWS
S I P N T J 2 2 B 1 0 2 - D W S 2 0 0 0 0

NOTA ПРИМЕЧАНИЕ

Dimensions of gantry girders, quadrilateral beams and trolley have to be confirmed for final configuration of catching area

Для конечной конфигурации зоны захвата размеры ферм кранового портала, четырехгранных балок и троллей должны быть подтверждены

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ENGINEER	ИНЖЕНЕР
THE PROJECT MANAGEMENT UNIT (PMU)	ГРУППА УПРАВЛЕНИЯ ПРОЕКТОМ (ГУП)
ЧАЕС, BECHTEL, EDF, Battelle ... Putting Technology To Work	
CONTRACTOR	ПОДРЯДЧИК
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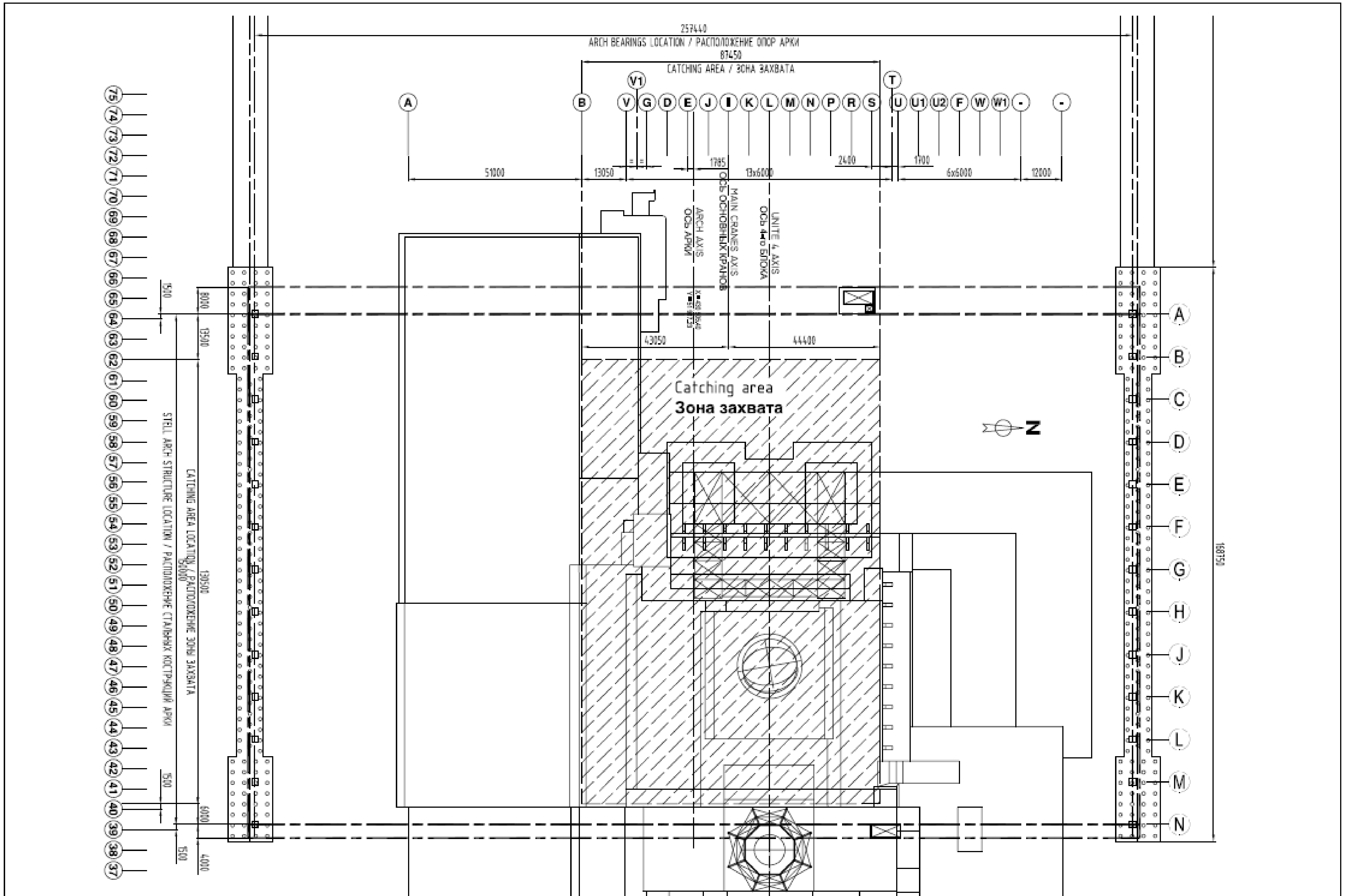
S I P	N	T E	2 2	B 1 0 2 -	D W G	0 0 1	0 0

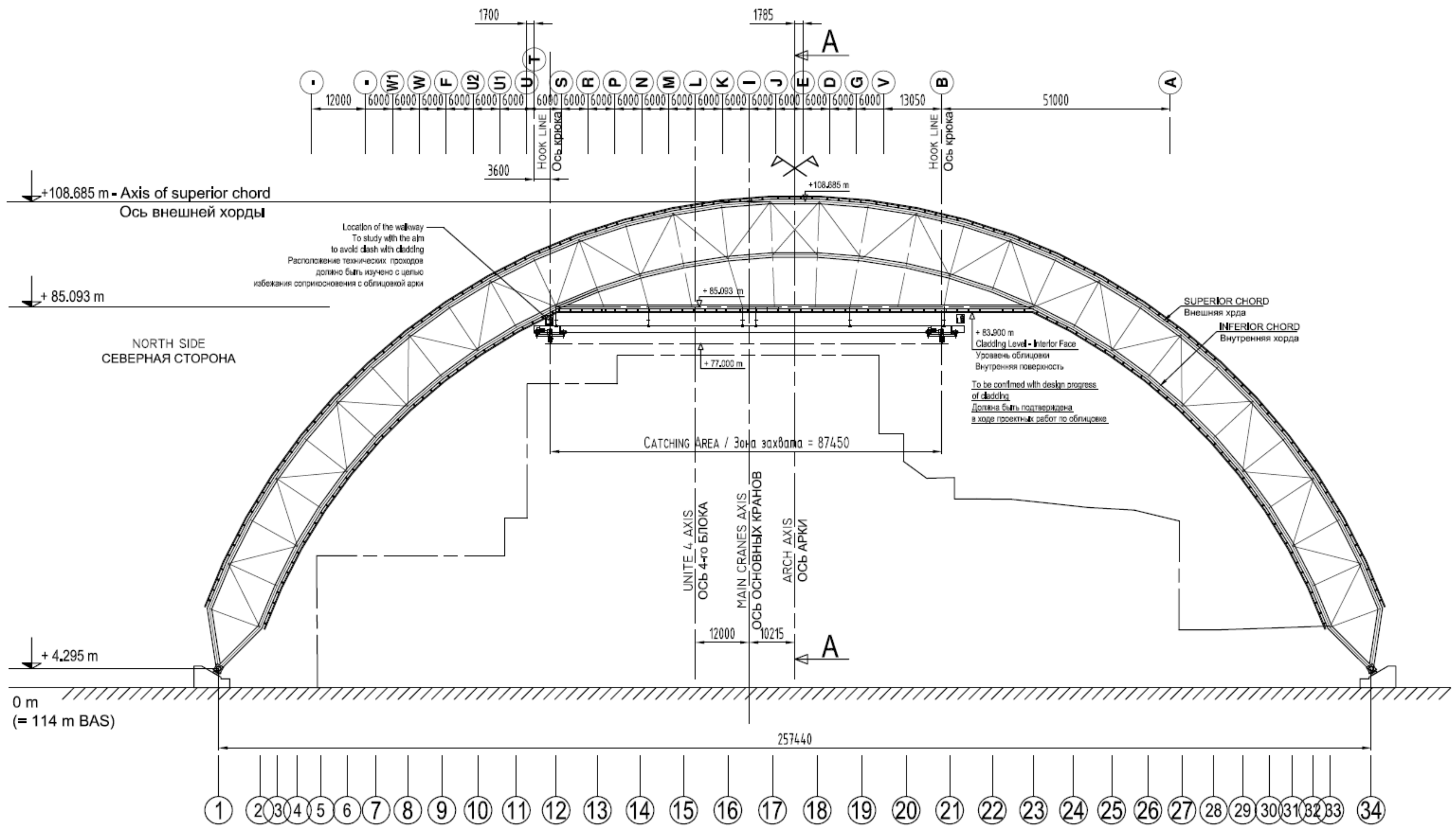
DOCUMENT TITLE	НАЗВАНИЕ ДОКУМЕНТА
MAIN CRANE CATCHING AREA	ОСНОВНЫЕ КРАНЫ ЗОНА ЗАХВАТА

ENGLISH VERSION	RUSSIAN VERSION	АНГЛИЙСКАЯ ВЕРСИЯ	РУССКАЯ ВЕРСИЯ

0 0	2008-05-19	MLD	FCO	PRE	First Issue	MW
Rev. Ред.	Date Дата	Prepared Подготовил	Checked Проверил	Status Статус	Reason for Revision Причины изменения	Approved Утвердил



MAIN CRANE CATCHING AREA PLAN VIEW	ОСНОВНЫЕ КРАНЫ ЗОНА ЗАХВАТА ВИД СВЕРХУ	Chernobyl New Safe Confinement – Contract N° SIP08-1-001 SIP-N-TE-22-B102-DWG-001-00 PAGE: 2/4 ЛИСТ:



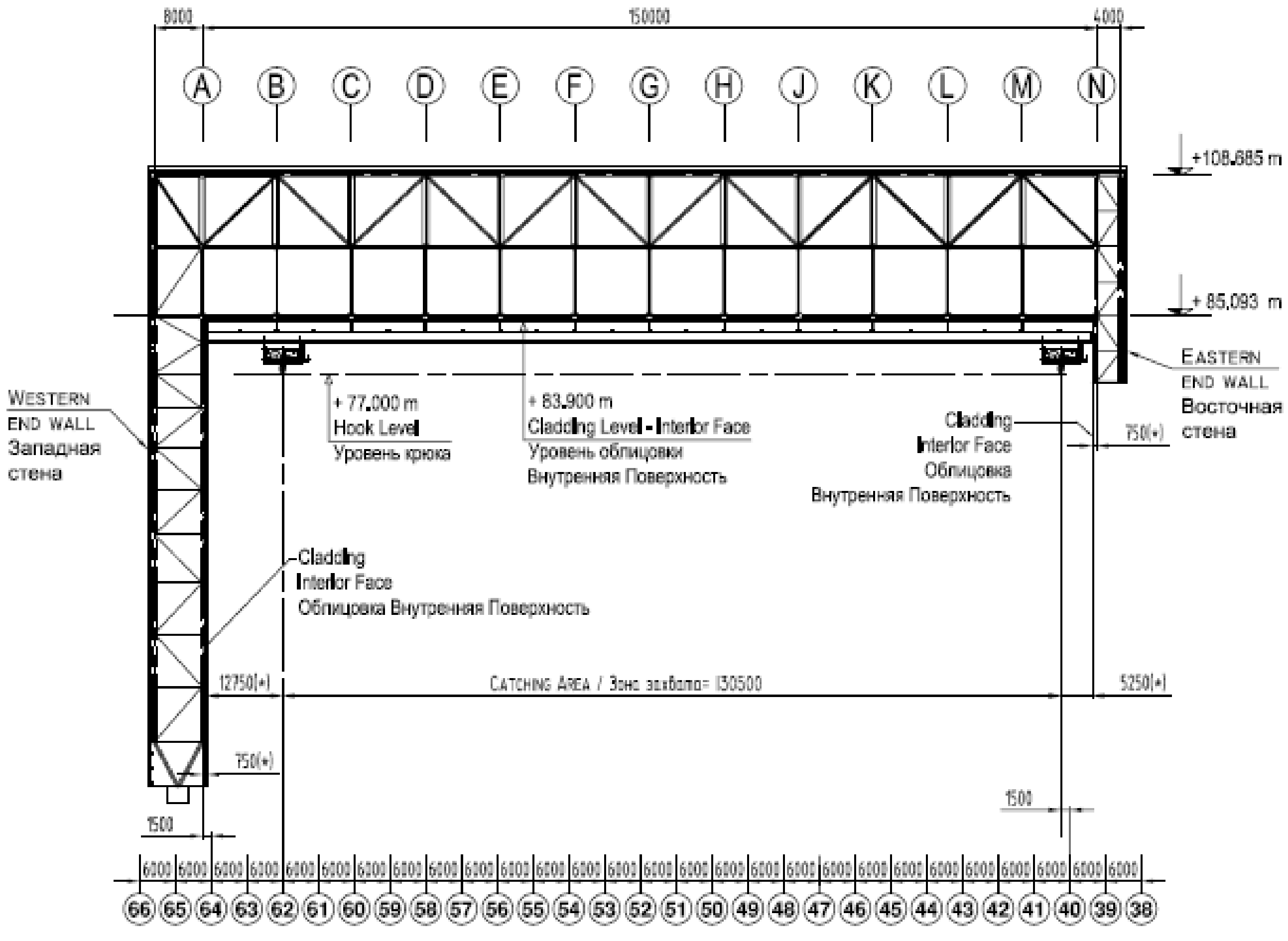
MAINE CRANE
CATCHING AREA
TYPICAL CROSS SECTION

ОСНОВНЫЕ КРАНЫ
ЗОНА ЗАХВАТА
ПОПЕРЕЧНОЕ СЕЧЕНИЕ

Chernobyl New Safe Confinement – Contract N° SIP08-1-001

SIP-N-TE-22-B102-DWG-001-00

PAGE: 3/4
ЛИСТ:



(*) Dimensions to be confimed with design progress of cladding
Размеры должны быть подтверждена в ходе проектных работ по облицовке

A1.1 West end wall

The structural layout of the western end wall consists of a system of vertical truss columns and horizontal truss girders as the main bearing structure, and a lattice of columns and beams as a filler structure in between.

During sliding, the west end wall is entirely suspended from the arch. In service it is partially suspended and supported vertically on two central lattice columns with their own foundations. The secondary columns of the wall are blocked horizontally in the east wall direction. There is no structural joint between the outer arch and the west wall structure. The space between the two wall claddings is thus in continuity with the arch annular space.

The depth of the spatial girders of the west wall is 8 m. The inner face of the west end wall closes off the arch structure, so that the wall is basically outside of the arch structure.

A1.2 East end wall

The east end wall consists of a spatial frame being entirely supported by the arch structure and transferring no forces to the existing structures. The depth of the spatial truss frame is 4 m.

The east end wall rests on its own foundation and is connected to the additional 15th arch. There is no structural joint between the outer arch and the east wall structure. The space between the two wall claddings is thus in continuity with the arch annular space.

The inner face of the east end wall closes off the arch structure, so that the wall is basically outside of the arch structure.

A1.3 Maintenance of the steel structure

For the steel structures, maintenance is normally necessary in order to guarantee the structural safety and to ensure the service requirements throughout the design working life.

However due to the radiation risks at the NSC, the arch structure is designed to fulfil its design working life without requiring any subsequent maintenance.
Firstly the design with the relevant criteria and code respects will ensure the structural safety and service requirements.

Secondly the quality and the control of fabrication will ensure the structural integrity and the satisfactory behaviour of the structure during its design working life.

Structural monitoring will be provided in order to ensure that the global behaviour of the structure stays in conformity with the design.

In order to protect the structural steel after fabrication up to early operation of the shelter the steel sections will be covered with a multi-layer protective coating system meeting requirements for long life system.

The steel arch structure is completely enclosed in the annular space between the internal ceiling and external roofing where the temperature and humidity will be permanently controlled in order to avoid condensation. The same design is applied to the West and East walls. This ensures that corrosion of the steel structure will not be initiated and will not be able to develop in the long term.

At the connections the bolt fasteners will be hot-dip galvanised.

All the corrosion protection systems will be defined by a specialist with regard to long term behaviour under radioactive exposure.

In addition inspection facilities will be provided to check the absence of corrosion and to ensure access to some pre-selected connections. This will be done at regular intervals and after accidental events.

For inspection of the lower chords structures, access will be provided at the crane tie-beam framing plan (around level +85m level). Access will be done through the lift and stairs located in the west wall. One transversal and three longitudinal walkways will be provided in the annular space above the travelling cranes supports.

Moreover on the lower chord of the western end arch, pilot nodes from arch bottom to level of travelling crane supports will be accessible.

The access made of gangways stairs or ladders according the slope will be fixed on the lower chord.

Some access footbridges may be provided at the lower parts of the arches in order to inspect the steel structure at the bottom part of the arch and the pot bearings. A system will be provided for the replacement of these pot bearings when needed.

A2 FOUNDATIONS

The NSC steel arch will be supported by 2 ground beams, North and South of the arch.
The vertical and horizontal loads applied to these beams make necessary to found the beams in the « erection zone » as well as in the « service zone » on piles. These piles will minimize settlement and horizontal displacement of the beams
The sections of beams between those 2 zones do not need piles as the sliding operation will be performed during a suitable weather window (lower constraints).

In order to allow safe construction of the arch in an area with less exposure to radiation, the total length of the foundation (temporary and final) is increased up to 495m (West Side).

For the same reason, the end walls (eastern and western) are erected before sliding and not in the vicinity of the Object Shelter.

The planned sliding is carried out in steps using jacks. Within each step, the sliding is continuous.

A2.1 Soil Parameters

The reference document for the soil parameters is the *soil analysis report* n° FD 303. The soil profile can be defined as follows:

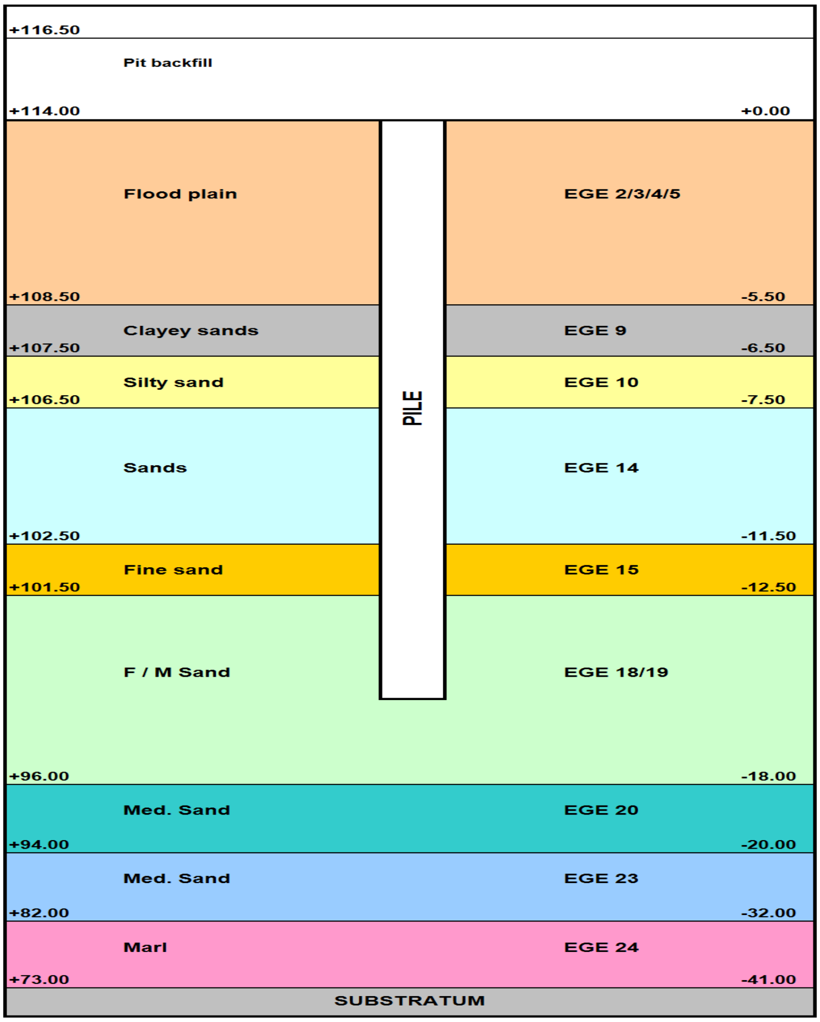


Figure A3. Soil cross section

A complementary soil investigation will be performed by Novarka in order to confirm the data given in the report n°FD 303.

This complementary soil investigation is described in the next page (See drawing n° SIP-N-TE-22A7040-DWC-001-Rev 01).

Ссылка: Спецификация N° SIP-N-TE-22-A7040-TSN-001
Ref.: Specification n° SIP-N-TE-22-A7040-TSN-001

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EMPLOYER	ЗАКАЗЧИК
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ENGINEER	ИНЖЕНЕР
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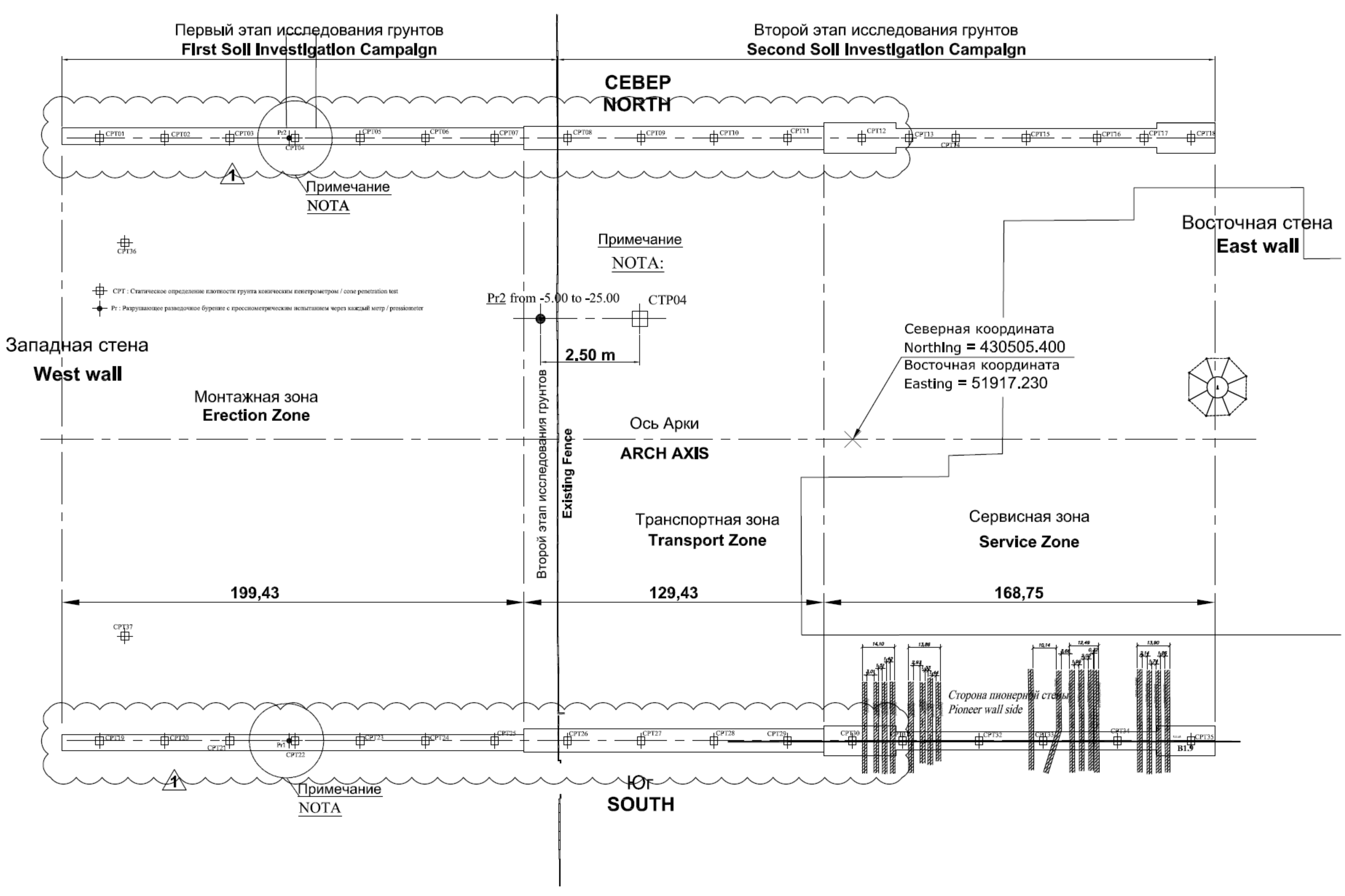
S I P	N	T E	2 2	A 7 0 4 0	D W C	0 0 1	0 1

DOCUMENT TITLE	НАЗВАНИЕ ДОКУМЕНТА
COMPLEMENTARY SOIL INVESTIGATION	Дополнительные исследования грунтов

ENGLISH VERSION	RUSSIAN VERSION	АНГЛИЙСКАЯ ВЕРСИЯ	РУССКАЯ ВЕРСИЯ

Rev. / Ред.	Date / Дата	Prepared / Подготовил	Checked / Проверил	Status / Статус	Reason for Revision / Причины изменения	Approved / Утвердил
01	2008-06-25	MLD	FCO	PRE	Updated after PMU comments (PMU-NKA-NSC-146)	MWA
0 0	2008-02-06	MBE	FCO	PRE	First Issue	MWA


Первый этап исследования грунтов
First Soil Investigation Campaign
Второй этап исследования грунтов
Second Soil Investigation Campaign
СЕВЕР
NORTH
Примечание
NOTA
Примечание
NOTA:
Pr2 from -5.00 to -25.00
CTP04
2.50 m
Восточная стена
East wall
Западная стена
West wall
Северная координата
Northing = 430505.400
Восточная координата
Easting = 51917.230
Монтажная зона
Erection Zone
Второй этап исследования грунтов
Existing Fence
Ось Арки
ARCH AXIS
Транспортная зона
Transport Zone
Сервисная зона
Service Zone
199,43
129,43
168,75
Сторона пионерной стены
Pioneer wall side
Примечание
NOTA
ЮГ
SOUTH

Объект «Укрытие» ЧАЭС
CHERNOBYL SHELTER

Координаты замеров
Coordinates of Soundings

1

Координаты замеров Coordonates of Soundings				
Замеры SOUNDINGS	СЕВЕР NORTH	ВОСТОК EAST	Верхний уровень UPPERLEVEL	Нижний уровень LOWERLEVEL
CPT01	430635.620	51592.060	0,00	-25,00
CPT02	430635.620	51620.190	0,00	-25,00
CPT03	430635.620	51648.310	0,00	-25,00
CPT04	430635.620	51676.440	0,00	-25,00
CPT05	430635.620	51704.560	0,00	-25,00
CPT06	430635.620	51732.690	0,00	-25,00
CPT07	430635.620	51762.550	0,00	-25,00
CPT08	430635.620	51794.140	0,00	-25,00
CPT09	430635.620	51825.740	0,00	-25,00
CPT10	430635.620	51857.340	0,00	-25,00
CPT11	430635.620	51888.930	0,00	-25,00
CPT12	430635.620	51921.130	0,00	-25,00
CPT13	430635.620	51941.440	0,00	-25,00
CPT14	430635.620	51961.750	0,00	-25,00
CPT15	430635.620	51992.060	0,00	-25,00
CPT16	430635.620	52022.680	0,00	-25,00
CPT17	430635.620	52042.990	0,00	-25,00
CPT18	430635.620	52063.300	0,00	-25,00
CPT19	430375.180	51592.060	0,00	-25,00
CPT20	430375.180	51620.190	0,00	-25,00
CPT21	430375.180	51648.310	0,00	-25,00
CPT22	430375.180	51676.440	0,00	-25,00
CPT23	430375.180	51704.560	0,00	-25,00
CPT24	430375.180	51732.690	0,00	-25,00
CPT25	430375.180	51762.550	0,00	-25,00
CPT26	430375.180	51794.140	0,00	-25,00
CPT27	430375.180	51825.740	0,00	-25,00
CPT28	430375.180	51857.340	0,00	-25,00
CPT29	430375.180	51888.930	0,00	-25,00
CPT30	430375.180	51916.980	0,00	-25,00
CPT31	430375.180	51938.720	0,00	-25,00
CPT32	430375.180	51971.750	0,00	-25,00
CPT33	430375.180	51999.490	0,00	-25,00
CPT34	430375.180	52031.420	0,00	-25,00
CPT35	430375.180	52063.300	0,00	-25,00
CPT36	430590.400	51603.000	0,00	-25,00
CPT37	430420.400	51603.000	0,00	-25,00
Pr1	430375.180	51673.940	-4,00	-34,00
Pr2	430635.620	51673.940	-4,00	-34,00

СЕВЕР
NORTH

ВОСТОК
EAST

NB : уровень 0.00 = + 114.000 (BAS)

NB : level 0.00 = + 114.000 (BAS)

A2.2 Pile bearing capacity

Pile bearing capacity is determined from in situ cone penetration tests. The ultimate soil strength qc is used to quantify the ultimate bearing characteristics either for skin friction or for end bearing.

In the arch final position the piles will support in ULS (Ultimate Limit state) a vertical load of 580 T, and a horizontal load of 150 T. These loads shall be confirmed or up-dated during the design stage. In order to avoid vertical and horizontal displacements, the piles must provide:

- A vertical bearing capacity, provided both by friction effect of the ground in place and by point load ground resistance;
- A horizontal resistance to deformation provided by the ground (depends on the ground characteristics and the diameter and depth of the pile).

A2.3 Concrete and Reinforcement

Concrete class is C40/55 in order to achieve a life span of 100 years.

In structural design of the piles, a characteristic compressive strength of 25 MPa is used (according to Fascicule 62 titre V).

For the concrete beams, a characteristic compressive strength of 40 MPa is used.

Steel bars for reinforcement are of E500 grade, thus yield strength of 500 MPa.

A2.4 Interface of the Arch Foundations and the existing structures

The interface with the existing structures shall take into account the underground structures (many pipes and outlets) crossing the future foundation and also the buildings already built on site.

This interface needs additional accurate surveying (not yet available) in order to hone the design of the foundation. The design phase will start as soon as the results of this survey are available.

Special Foundations at the location of the cooling pipes (2m dia.) under the southern Service Foundation Area: at this stage and after checking the soil properties, it is planned to adapt Continuous Flight Auger (CFA) piles to a depth of 18m (Values on diameter and length to be confirmed by onsite survey) below the level 113.5 BAS. This depth is 3m lower than the common piles used elsewhere (15m under level 113.5). These piles have to be drilled specifically between the 17 cooling pipes and around the concrete outlet into the cooling pond.

In order not to overload the pipes, these piles are equipped with a sacrificial casing at the top, this preventing friction between soil and pipes.

The actual design increases the length of the footings westwards in order to practically avoid exposure during the arch construction. This extension requires the demolition of a small part of the changing facility building on the north side of the temporary foundation.

A2.5 Foundation and sliding system's architecture and sizing:

The foundations are dimensioned with respect to loads calculated using 3D models of the Arch. The bearings of the arch are located on a inclined plane (33° from horizontal) in order to minimize the transverse reaction on support.

The construction of the footing is carried out with elements approximately 10m long.

A2.6 Arch foundations in Service Area

The foundations are made of 2 footings of around 168 m length on piles of diameter 1000mm and 15m length. Each footing is divided into 3 sections, 53m, 62m and 53m allowing to support respectively 5, 6, 5 arches for the west end part, the central part, and the east end part correspondingly.

For the south foundation, in proximity to the power plant, the piling system will be honed during the final design stage taking into account the existing underground pipes.

The governing cases for bearing capacity are the main combinations at serviceability limit state.

Each part of the footing is 4.845 m thick (max) with a top face sloped at 33° in order to install a single pot bearing limiting the transverse reaction.

For pile reinforcement, the governing case is the main combination at ultimate limit stage. The maximum ratio section of rebar is 2% of the pile section in order to enable a workable insertion of pile reinforcement cage into ground beam cage.

A2.7 Foundations in erection area

The relevant area is located at the west end of the existing power plant. In this zone, the support reactions are reduced. Foundations consist of two footings around 168 m long and 7m wide.

In this area, the pile foundation could be necessary in order to minimize the settlements during the structural erection and tests of the travelling cranes.

The criteria for the settlements during tests will be defined at the following stage.

This footing will be divided into 3 parts (53m, 62m and 53m) with 2 expansion joints to take into account temperature changes.

Supplementary foundations (spread footing) are built in this area for temporary support of the arch structure during its erection. Their location depends on the selected construction method.

A2.8 Foundations in transportation area

In this area, the foundations consist of a spread footing 10m wide at elev. 114m. On one hand, most of the settlement occurs under the load of the concrete beam. On the other hand, the steel structure will be translated during weather window, so the loads will be less important than loads expected during service time. Moreover, the travelling cranes are not operating during this sliding phase and so the settlement criteria are less severe than those at final arch location.

The foundation is approximately 158m long.

The bearing capacity under construction loads, including the wind load, is determined according to Eurocodes.

The bearing capacity is determined according to the cone penetration test strength qc, given in the soil analysis report n°FD 303.

The characteristic value is calculated from the average of the first 15m, and the reference stress, which is used as the criteria of bearing capacity, is 0.2 MPa. A rough estimate of short-term settlements gives a maximum value of 30mm and a horizontal deflection of 12mm.

A2.9 General description of the chosen foundation technology

A2.9.1 Available techniques

Different piling techniques are available. Their domain of application in Chernobyl depends on several factors:

. Type of ground (hard, soft, compressible or not);
. Diameter of the pile;
. Presence of a water table (under water the ground must be supported);
. Vibration level during construction (low particle velocity close to the OS);
. Production of waste.

- Barrettes piles and bored piles:

Type of foundation using bentonite slurry as a ground support during excavation. Such techniques involve a great quantity of slurry which would be contaminated. In addition a lot of spillage is produced

- Bored piles through a steel casing:

Bored piles carried out with the protection of a temporary casing in the ground water table. This technique involves longer piles (less friction) hence more materials, and pumping the water in the excavation during concreting.

- Driven steel pipes:

Driven steel pipe using an oscillator down to founding depth.
Due to the uncompressible nature of the ground this technique cannot be used.

- Driven H piles:

This technique implies high a vibrating energy to drive the pile in dense sand, hence high particle velocity applied to the OS.

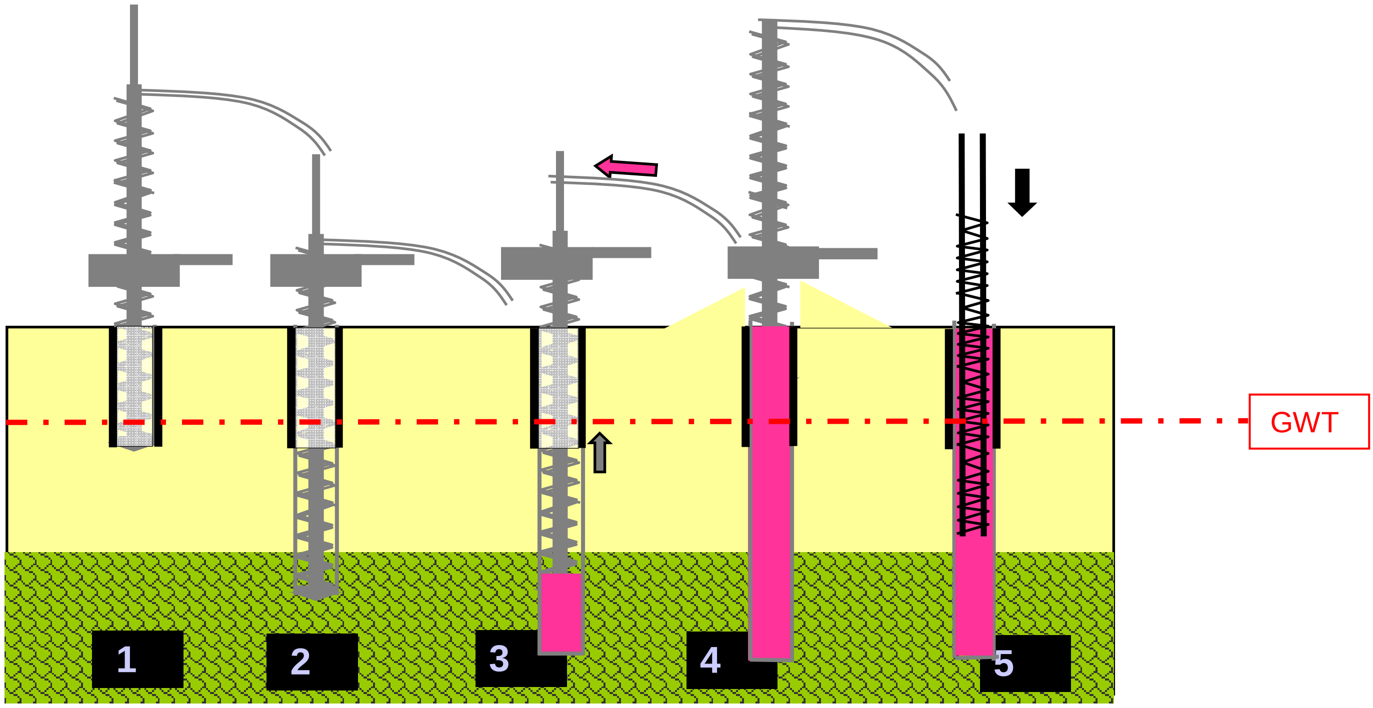
- Displacement piles:

This technique using an auger is the only one which does not need to extract the spoil, as the ground is compacted in place. The experience is limited to 600 mm in relatively compressible soil. This is not applicable to Chernobyl conditions.
CFA (Continuous Flight Auger) piles:
This technique utilises a continuous fly auger down to the required depth; the concrete is then pumped from bottom up through the hollow auger while the auger is extracted and the spoil removed.
When the concrete reaches the top ground level the reinforcement steel cage is introduced into the fresh concrete to the required depth by its own weight or assisted by a vibrator.

5.1.1.1 NOVARKA technical assessment and decision

Novarka has reduced its original design from 1200 mm to 1000 mm to remain within standard equipment and experience.
Using vibrators to drive piles in the uncompressible dense sands would need high energy hence high vibrations applied to the Shelter Object.
The experience with techniques using compaction of the ground in place is not conclusive in dense sands like in Chernobyl. Moreover reducing the diameter to less than 1m (500 mm ?) would lead to much bigger quantities of spoil and risk of exposure to radiations.

The <u>decision is therefore to use CFA piles in the « service zone</u> ». The drawback of the methodology in Chernobyl environment is that the extraction of spoil has to be fast enough to avoid concrete setting (steel reinforcement to be introduced: 5 below).



Phase 1: Start excavating with auger after isolating the first meters with a steel casing
Phase 2: excavation below water table down to the bottom of the pile
Phase 3: start concreting and beginning of extraction of spoil
Phase 4: end of concreting and start of spoil treatment
Phase 5: steel reinforcement cage introduced in fresh concrete

A technical assessment of the conditions in the « erection zone » is still underway.

5.1.1.2 Consequences for NOVARKA construction methodology and organisation

NOVARKA is developing methods of works to be able to manage safely the potential contaminated material extracted from the ground.
In particular, special treatment and attention is brought to the first 3 to 4 meters of the excavation.

These issues have been preliminarily addressed with the expert organisation during CDSD development. Minutes of meetings and copies of technical correspondence are annexed to this document.

A2.10 Solution for the structure of the Arch foundations and sliding system

It is planned to use pot bearings (temporary and permanent bearings) to slide the arch during the construction phases and for the sliding into the final position.

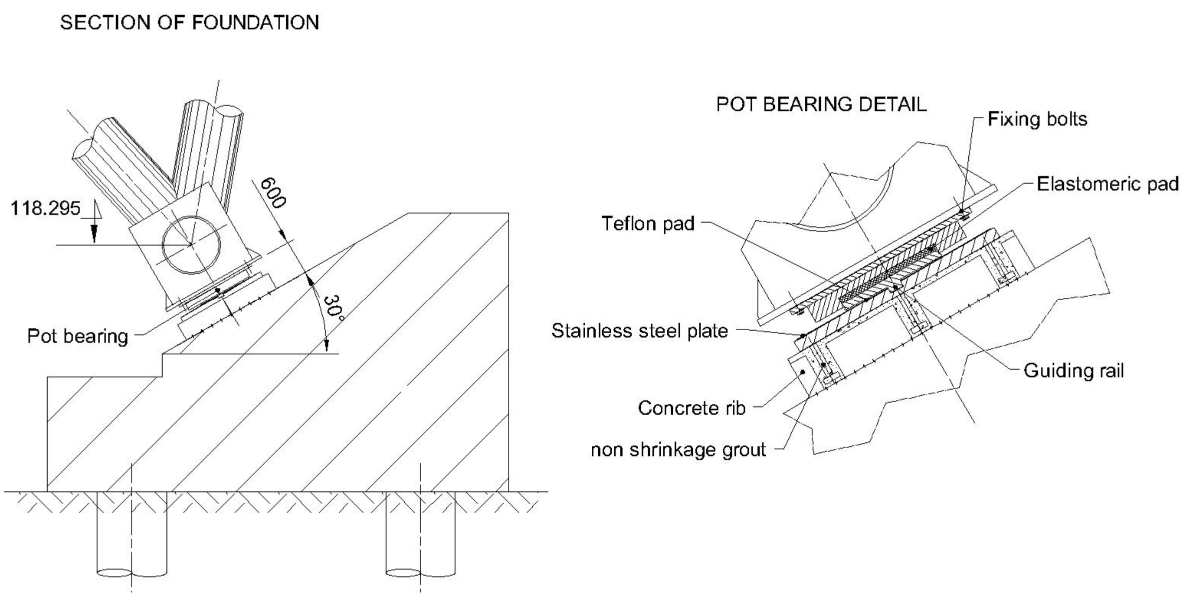


Figure A4 Pot bearings

The bearings mainly consist of a steel pot with an elastomer pad and a steel lid. The elastomer pad is totally insulated within the pot with interposition between the pot and the lid of an anti-extrusion joint. When subject to vertical and horizontal loads, the pot acts as an incompressible fluid so that it allows a rotation, thus hydrostatic equivalent pressure is always uniform.

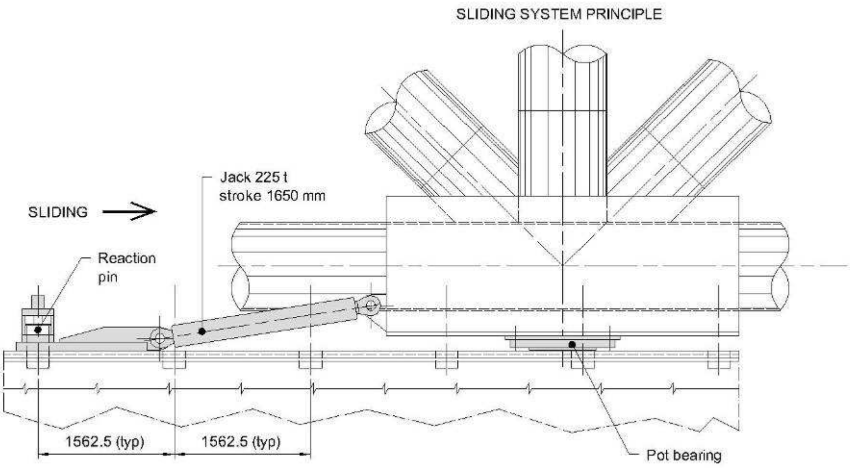


Figure A5 Sliding system principle

A3 CLADDING & ROOFING

A3.1 Presentation

The roof and the end walls are constitutive of two skins – an external skin and an internal skin - fixed 13m from the roof and between 4m to 8m for the east and west walls.

The void thus created will be ventilated at such temperature and relative humidity rate that no condensation and only limited corrosion (if any) will appear.

A3.2 Function of the skins

A3.2.1 External skin

- To withstand climatic actions: snow, wind, tornado class 1.5, temperature;
- To withstand tornado class 3 but with permanent deformation due to yielding of steel material, in order to fulfil the criteria c & d of A03 paragraph 3.1.4.11;
- To withstand maintenance and service loads;
- To give the proper thermal insulation in order to control the inside temperature of the annular space as required by the ventilation design;
- To minimize the roof and cladding air leakage in order to control the flow of air ventilation in the annular space;
- To keep its properties at workable level while subject to radiation.

There is no requirement with regard to confinement which is ensured globally by the annular space overpressure and the internal skin

A3.2.2 Internal skin

- To withstand the specific climatic actions during the stages of shelter construction;
- To withstand the internal pressure of the annular void;
- To withstand the maintenance and service loads;
- To ensure the confinement of the shelter with regard to contaminated dust;
- To keep its properties while subject to radiation.

None of the skins are designed to be radiological barriers.

A3.3 Inspection and maintenance

Inspection will be possible from the outside of the roof skin via a gondola which will be equipped to protect workers from radiation effects. It will only be allowed on the inner skin when the contamination of the main volume is acceptable for the presence of personnel.

The gondolas will run on tracks protruding outside of the roof and the internal skin.

Light maintenance of the external skin and of the internal skin such as local repair of small dimensions will be possible but obviously limited by the level of radiation. It will not be possible to replace any external or internal skin panels.

However it is to be noted that the design of the components for roof and cladding as well as the choice of material will lead to a minimum durability of 100 years with minimum maintenance as explained above.

A3.4 Description of the skins

A3.4.1 External skin

Several possibilities are to be studied:

A) Basic solution

The external skin is constituted of:

- A corrugated galvanised steel decking which will support all the other components and which will transfer all the actions to the wall rails and purlins;
- A vapour barrier whose function is to stop the migration of the air vapour;
- A network of cold formed omega profiles to support the halters on which will rest the external ribbed decking;
- A first layer of rigid mineral fibre of thickness equal to the height of the omega profiles;
- A second layer of insulation. Taken together the thermal insulation materials shall give thermal transmission factor $K \leq 0.5W/m^2/°C$;
- An external ribbed decking made of aluminium or stainless steel material of grade and quality to be defined to withstand a minimum of 100 years. The joints of this decking will be welded on site, in order to ensure the proper air tightness.

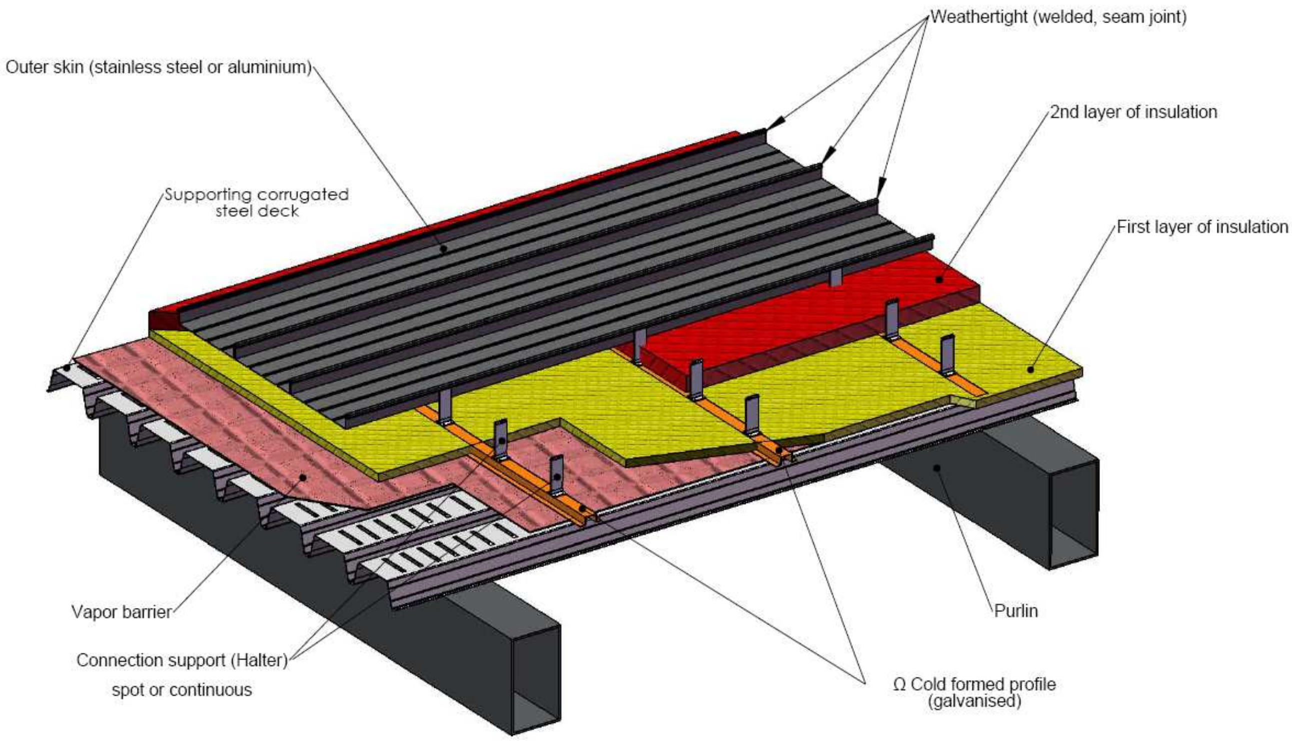


Figure A6. Baseline External skin option

B) First alternative

With regard to the basic solution it is to be investigated if an EPDM membrane laid on the first layer of insulation can be used in place of the welded seams of the external decking.

In this case, the EPDM membrane and its joints will have to ensure the proper air tightness and will have to resist under radiation exposure for 100 years.

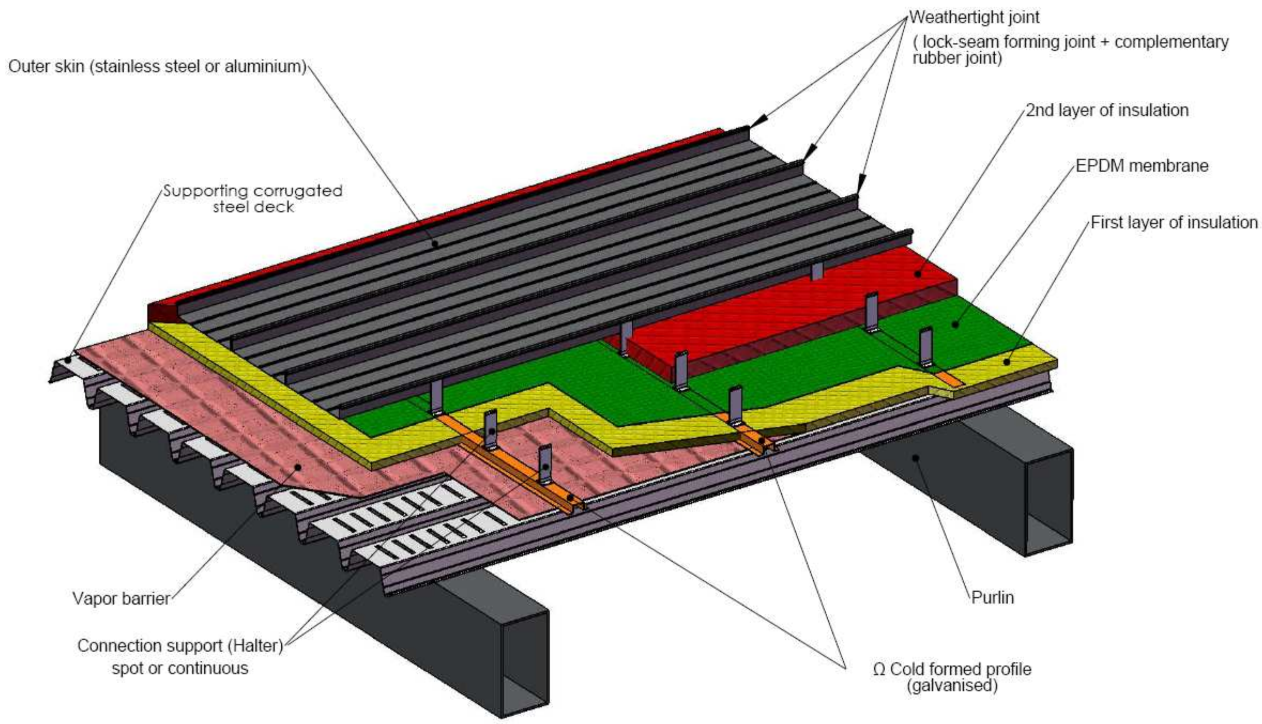


Figure A7. First roofing alternative

C) Second alternative

- A corrugated galvanised steel deck laid on a network of secondary purlins and rails. This deck will bear all the other components and will transfer all the actions to the rails and purlins;
- A layer of fibre-cement plates or a galvanized steel plate designed to support an EPDM membrane which will ensure the air tightness and assume the function of vapour barrier;
- A thermal insulation made of foam glass or rock wool or glass wool;
- An external skin made of corrugated stainless steel aimed to withstand the climatic actions.

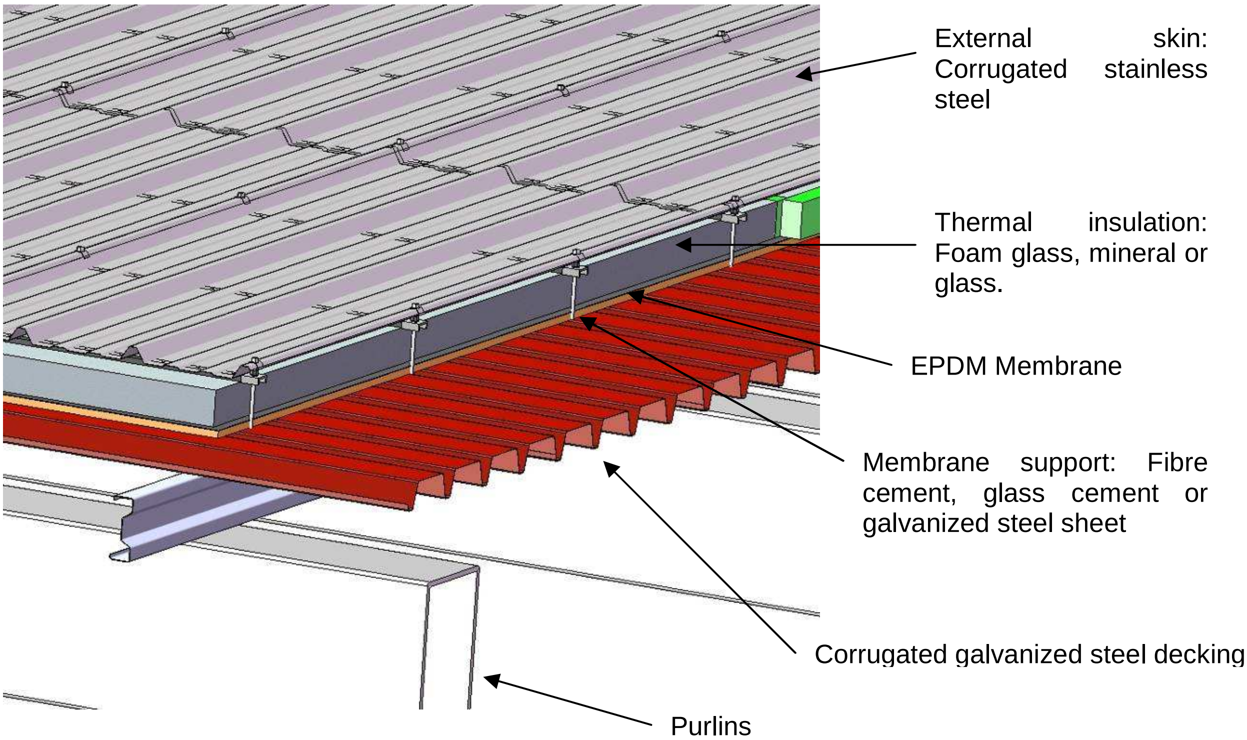


Figure A8. Second roofing alternative

D) Other alternatives

Other alternatives are possible providing they ensure the same functionalities.

5.1.1.3 Internal skin

This skin is constituted of a ribbed deck made of stainless steel for fire resistance and durability, supported by a network of rails.

Stainless steel material shall be a magnetic type.

Confinement will be achieved by either welding of the joint or by providing radiation resistant and durable sealing joint and/or an EPDM membrane.

Alternatively the stainless steel decks may be connected a support made of a galvanised metal decking.

A4 MAIN CRANES

This chapter shall be read in conjunction with the Technical Specification: Main Cranes System – Ref: TS 301 – Section 16 in Rev C and the attachment 1 to this specification. (Chap 7 – Appendix 6)

The main cranes system shall be designed in accordance with the latest applicable

- European norms.
- FEM 1.001 3rd edition revised 1998.10.0 calculation rules.

The minimum sizing of cranes shall comply with the following group classification (F.E.M. Book 2):

Table A1. FEM Groups used for the sizing of cranes

CRANE COMPONENT TO BE SIZED	FEM GROUP
Structure	Group A6
Mechanism	Group M5 (only secured carriage rope is M8)
Components	Group E5

The main cranes system will comply with the Ukrainian Norms. The compliance Certification will be made by a third party.

The main cranes system will provide access to SO upper structures between the northern buttress wall and the octopus beam. Usual configuration is two northern and two southern quadrilaterals.

The arch is equipped with 4 quadrilaterals moving East-West and 4 carriages as described below.

The arch is equipped with two garages for carriage, one for maintenance and decontamination purpose, another for operation purpose (change or storage of carriage). Maintenance garage is located over the initial treatment area between row T-U2 and axis 60-63. The storage garage is located on the south side of row B at axes 56-58 above the turbine hall.

The main handling equipment within NSC is supported by the NSC arch, and their characteristics are described here below.

A4.1 General

A4.1.1 Operation conditions

Table A2. Operation conditions

CRANE COMPONENT TO BE SIZED	FEM GROUP
Environment	Interior
Temperatures	-22 to +29℃.
Gamma radiation level	0.1 to 1Gy/h (at the top of the mobile tool platform)
Humidity	100%
Building lighting	200 lux (at ground level)

The quadrilaterals and / or carriages must withstand the Maximum Design Earthquake. The associated requirements are:

- The quadrilaterals and / or carriages and its components shall not drop during and after an earthquake.
- The load handled by the carriages shall not fall under an earthquake solicitation.

After a Design Basis Earthquake, the handled load must not fall. Moreover, it will be possible to restart the quadrilaterals and / or carriages to drive them back to their park, providing minimum repair at contact.

A4.1.2 Crane controls

The main cranes system is controlled:

- In normal operating mode, from the NSC Control Room, located in the NSC auxiliary building.
- For specific operations or maintenance, using a remote control (radio controlled push button controls) from within the NSC. This control post can be used inside the NSC building (close to the quadrilaterals) or from the quadrilaterals / carriages where ever they are located, above a work zone or in a garage.

A4.1.3 Technical description

- Quadrilaterals and carriages can be either underslung (suspended, under running) or supported (top running).
- Each quadrilateral is mounted on track-ways fixed on the arch main structure.

- 3 types of carriages capable of moving on the 4 quadrilaterals, the carriages can be transferred from one quadrilateral to another (North-South direction) with their full loading capacity.

The equipment consists of:

- 4 quadrilaterals;
- 2 x 500 kN «classic» carriages;
- 1 x 400 kN «specific» carriage;
- 1 carriage equipped with a mobile tool platform. The mobile platform tool platform is either a telescopic mast or an equivalent device.

A4.2 Quadrilaterals

A4.2.1 General

- Quadrilaterals can be either underslung or supported.
- Quantity: 4.
- Overall Span: 42 m, using 2 (1 span).or 3 (2 spans) track runners.

A4.2.2 Framework

- The maximum deflection of the beams between two consecutive lines of rails is 1/1000 of the reach.
- Walkways give access to the carriages.
- An emergency support device is designed onto the beams for each rail to avoid a fall in the event of a failure in one of quadrilateral translation mechanisms.
- Each end of the quadrilateral walkways (North of Northern cranes and South of Southern cranes) is fitted with an access gate, opening inwards and fitted with a positive locking device as well as an 'opening detector', giving access to the skirt ladder or stair.
- This ladder or stair gives access to the building gangway, around axis T (North) and Axis B (South).
- Planking is used to access the translation bogies (access to motors and bogies wheels by man-way for maintenance purpose).
- The ends of the beams on the building side (North & South) are cantilevered under the track runners to extend the zone covered:

  – North side: The Northern Buttress Wall.
  – South side: The Octopus Beam.

- The quadrilaterals are sized for the following loading cases:
  – The presence of one loaded carriage.
  – The simultaneous presence of two unloaded carriages.

The system is not designed for the use of a second carriage when there is already one loaded carriage in use (the carriage equipped with the mobile tool platform and the specific carriage with the protective box are loaded carriages).

A4.2.3 Translation movement

- Travel: 144 m approx.

- Speed: variable, up to 15 m/min, minimal speed ≈ 1 m/min.

- Automatic positioning accuracy in the order of ± 20 mm.

- Translation movement is forbidden during lifting.

- Bogies are used to move the quadrilateral.

- For translational movement, the quadrilaterals are fitted with reducing gear motors for each rail. Each caged motor-gearbox is fitted with an integral braking system and is controlled by frequency inverter, giving progressive acceleration and deceleration.

- The translational movement is fitted with an encoding (counting) device.

- 2 limit switches and 2 directional switches are provided at the end of each track runners.

A4.3 "Classic" carriages with lifting capacity of 500 kN (Ref to § 5.4.2)

A4.3.1 General

- Carriage can be either underslung or supported.

- Quantity: 2.

- Carriage, fitted with one cable winch.

- Designed to handle metallic structures and large concrete element or to be used with skips and grappling hooks.

- The electrical cabinets are fixed to the carriage itself.

A4.3.2 Lifting movement

- Capacity: 500 kN vertical load lifting at the ring on the pulley block.
- Lifting speed: variable, up to 10 m/min.
- Automatic positioning accuracy in the order of ± 10 mm.
- Lifting is not authorized during translation and / or directional movement,
- Lifting distance: 75m (from +6m to 77m).
- Pulley block:
  - Fitted with a rotating eyebolt (rotation ± 180°).
  - Fitted with an electric take–up device, supplying the rotating pulley block and connected tools.
  - Provisional offset power: 55 kW.
- High speed feeder:
  - 1 motor, with speed controller.
  - 1 operating brake, consisting of a clamping device and a disk coupling, linking the motor to the reducing gears.
- Cables: 2 left-right cables.
- Counterweight beam.
- Mechanically welded drum, fitted with a safety brake or equivalent device which stops vertical movement upon loss of electrical power.
- Parallel shaft reducing gearbox.
- Upper over-travel independent of the selector.
- For safety functions, limit switches with 2 contacts.
- Load management system.
- Fitted encoding device.

A4.3.3 Carriage chassis

Consists of:

- 1 Welded framework, consisting of a simple web of beams, commercially available sections or casings forming a rigid assembly.
- 1 access from above the quadrilateral (carriage in its garage position on the quadrilateral).

- 1 set of checker plate sheets in 4/6.
- 1 guard rail around the periphery.
- Electrical cabinets fitted to the carriage.

A4.3.4 Directional movement

- Speed: variable, up to 15 m/min, minimal speed ≈ 1 m/min.
- Automatic positioning accuracy in the order of ± 10 mm.
- Electrical power requested for translation devices is less than 15 kW.
- The directional movement of the carriage is by means of 4 drive units. Each unit consists of a caged motor-gearbox, fitted with an integral braking system and is controlled by frequency variation, giving progressive acceleration and deceleration. The braking system stops directional movement upon loss of electrical power.
- In the event of a breakdown in one of the four motor gearboxes, an operator, working from the circulation plating on the carriage chassis, can remove it.
- 2 limit switches and 2 directional switches at the end of each beam are provided.
- The directional movement is fitted with an encoding (counting) device.

A4.4 Specific carriage for personnel transportation into protective box

A4.4.1 General

- Carriage can be either underslung or supported.
- Quantity: 1.
- Carriage fitted with two cable winches (1 main, 1 back up). In case of trouble during operation, the system gives the possibility to take down the protective box to allow operators to go out and to lift it up to 50 m.
- Carriage designed for the movement of the 'protective box' (supplied by others).
- The electrical cabinets are fixed to the carriage itself.

A4.4.2 Lifting movement

- Designed to handle the protective box.
- Capacity of each cable winch: 400 kN at the ring on the pulley block.
- Lifting speed: variable, up to 10 m/min.
- Automatic positioning accuracy in the order of ± 10 mm.
- Lifting is not authorized during translation and / or directional movement.
- Lifting distance: coverage from level 6m to 75,2m.
- High speed feeder:
- 1 motor 75 kW, 1500 rpm motor.
- 1 operating brake, consisting of a clamping device and a disk coupling, linking the motor to the reducing gears.
- Cables: 2
- Counterweight beam.
- Mechanically welded drum, fitted with a safety brake or equivalent device which stops vertical movement upon loss of electrical power.
- Parallel shaft reducing gearbox.
- Upper over travel independent of the selector.
- Limit witch with 2 contacts.
- Pulley block:
  - Fitted with a rotating eyebolt (rotation ± 180°).
  - Fitted with an electric take–up device, supplying the rotating pulley block and connected tools or protective box.
  - Provisional offset power 55 kW.
- Load management system.
- Fitted encoding device.

A4.4.3 Carriage chassis

The design is similar to that of the "classic" carriage.

A4.4.4 Directional movement

The characteristics are similar to that of the "classic" carriage.

A4.5 Carriage equipped with mobile tool platform

A4.5.1 General

- Carriage can be either underslung or supported.
- Quantity: 1.
- Carriage, fitted with a mobile platform tool platform, designed to withstand a maximum horizontal force for the various tools of 1 500 daN and to be equipped with the following tools (weights are maximum not to exceed) (tools are supplied by others):
  - Concrete drill.
  - Carrier arm (2 tons).
  - Demolition jaw crusher or shearer (4.5 tons).
  - Vacuum cleaner for dust (loaded 10 tons, 5 tons unloaded).
  - Hydraulic unit (3 tons) to power the jaw crusher and drill.
  - 3 imaging cameras and lights.
  - Sensor for measuring gamma radiation.
- Note:
  The drill and jaws are fitted to the end of an articulated, 2.5m long arm. The drill and demolition jaw crusher cannot be fitted simultaneously. Tools changes must be carried out in the carriage maintenance garage. For calculation purpose only, as the eccentricity of loads is not specified, a load of 5 kN at 2.5 m is considered. This load is not an additional load to the one here above listed.

A4.5.2 Mobile tool platform

- The mobile tool platform can be used down to level 35 m.
- The device is lifted by means of one or several cable winches, fitted with encoder and a safety brake or equivalent device on the drum.
- Movement of the tool (lifting and rotation) is not authorized during translation and /or directional movement.
- The tool is capable of rotational movement by means of a directional ring, fitted with end-stops.
- Rotation: + or – 180°.
- Rotational speed: 0.5 rpm.
- Lifting speed: 10m/min.

- When the tool is extended, its horizontal movement velocity is limited. Moreover, the tool is fitted with a safety device for protection in the event of a collision with an obstacle or the tools becoming hooked. (A gauge is installed at mobile tool platform connection to measure the load. A quick release device avoids overload).

- A take up drum guarantees electrical supply to the tools on the mobile tool platform.
- A ladder provides access for maintenance of the hydraulic power unit when the mobile tool platform is in its upper position.

- Any deflection of the mobile tool platform does not prevent the tools from working.

A4.5.3 Carriage Chassis

The design is similar to that of the "classic" carriage.

A4.5.4 Directional movement

The characteristics are similar to that of the "classic" carriage.

A4.6 Track runners

- The quadrilaterals are designed to match the technical requirements either with 2 or 3 track runners.

- The quadrilaterals are either top running on the track runners (supported) or under running suspended to the track runners (underslung).

- Deformation of the arch structure or of the tracks runners does not prevent the quadrilaterals to operate.

- The tracks runners are attached every 12.5 meters.

A4.7 Transfer device

- The carriages are able to pass from any quadrilateral in the northern side to any quadrilateral in the southern side and vice versa or to a quadrilateral in the maintenance or garage zones (situated to the North and South of the quadrilateral track runners) in the following cases:

  – Passage of an unloaded carriage (one of the three types) to access a new work or storage zone.
  – Passage of a loaded 'classic' lifting carriage, for the handling of main beams structural elements or concrete blocks. This operation is limited.
  – Passage of the "specific" carriage, carrying the 'protective box'.

- The transfer operation is covered by a specific procedure. It is carried out in the following manner:

  - Pre-alignment of the two assemblies by the "command and control centre".
  - Mechanical locking between the quadrilaterals.
  - Electrical locking of the translation movement of the two quadrilaterals and the lifting movement of the carriage.
  - Removal of the end-stops.
  - Passage of the carriage.
  - No East-West translational movement is possible during transfer.

A4.8 Construction specifications

- The type of steel used quadrilateral and carriage frameworks takes into account low temperatures.

- The design of the lubrication devices and the choice of lubricants will be integral to the environmental conditions.

- The design of the structural steelwork is such as to limit retention zones, in order to facilitate equipment decontamination. In particular, all welds are continuous and sealed.

- Equipment is corrosion protected. The coating is a decontaminable paint.

A4.9 Electrical and command & control equipment

Electrical and command & control equipment take into account the following:

- The implementation of the 'carriage transfer' function.

- The equipment power (300 kW hydraulic unit, 75 kW lifting unit, etc…),

- Travel distances (144 m translation, 42 m directional),

- Equipment environment: height, radiation and contamination risk, access, maintenance.

A4.9.1 Power supply

- Electrical catenaries energize quadrilaterals and carriages. These catenaries are running along the track runners. The connections to mobile equipment are by means of sliding contacts.

- All motors are energized with 400V AC.

- The power bus fitted to the quadrilaterals and designed for carriages supply have, as a minimum, the following characteristics:

  - A system of 'double' sliding contacts, fitted to carriages in order to guarantee continuous power supply during transfer operations between quadrilaterals;

- An 'entry guidance' system fitted to the quadrilaterals to guide the sliding contacts during transfer operations between quadrilaterals;
- The provisional power for the quadrilaterals supply feeders is 500 kW (50 kW are dedicated for each quadrilateral permanent equipment including translation devices);
- The provisional power for the carriages supply feeders is 400 kW.

Note: In the garages, the power buses are supplied thanks to a connection to the main power bus.
The estimated powers here below must be confirmed during detailed engineering, as well as the maximum power supply.

Table A3. Power consumption of the cranes

COMPONENT	POWER CONSUMPTION
Quadrilateral	50 kW
Classic Carriage - Loading devices - Translation devices - Tools and Pulley **TOTAL**	 110 kW 15 kW 55 kW **180 kW**
Secured Carriage - Loading devices - Translation devices - Tools and Pulley **TOTAL**	 150 kW 15 kW 55 kW **220 kW**
Carriage with mobile tool platform - Loading devices - Translation devices - Platform and tools **TOTAL**	 75 kW 15 kW 300 kW **390 kW**

A4.9.2 Control & command equipment

- The electrical cabinets are fitted onto the mobile equipment (quadrilaterals or carriages).
- Depending on radiation levels around the equipment, radiological protection may be required (lead shielding, use of 'hardened' components or otherwise) in order to guarantee the equipment functions and reduce the maintenance interventions.

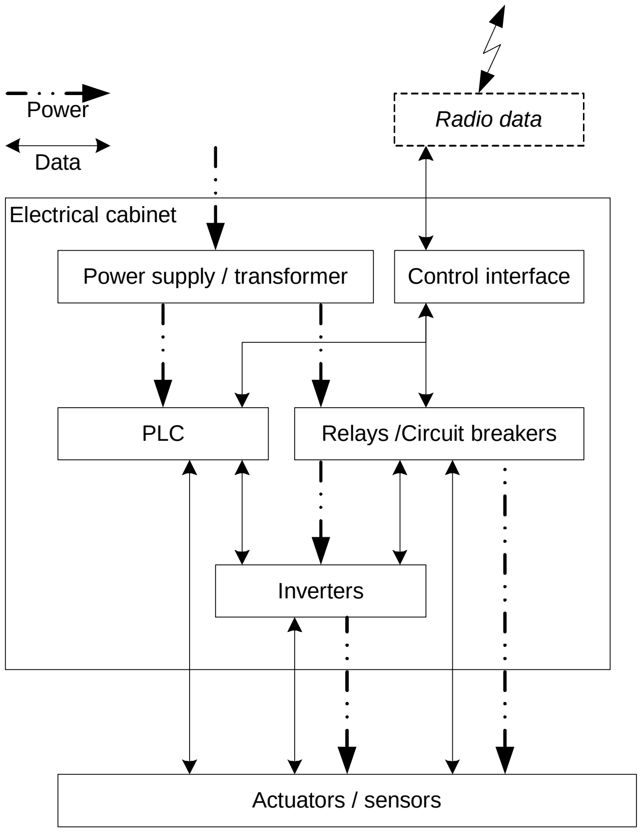


Figure A9. Circuit diagram of the on-board Instrumentation and Control system

A4.9.3 Automation

- The carriages and quadrilaterals are driven either from the control room or from a remote button box from within the NSC for maintenance operations.
- The carriages and quadrilaterals operate under three modes:
  - A limited maintenance mode, to carry out elementary movements.
  - A manual mode, the standard operating mode for the cranes.
  - An automatic mode, notably for:
    - The completion of predefined sequences or movements, of the 'return to lay-down area' type, etc.
    - The simultaneous, synchronized movement of two quadrilaterals or two carriages, for the movement of large, heavy elements such as beams.

The various configurations of the quadrilaterals and carriages are managed from the NSC control room cranes management system. This system authorizes all movements of carriages and quadrilaterals whether the order comes from the NSC control room or from a radio controlled push button control-box.

A4.10 Driving

A4.10.1 Control of the systems

The carriages and quadrilaterals are controlled in normal operating mode from the control room, in the auxiliary building of the NSC.

- Four driving positions are set with the following characteristics:
  - Each driving position is linked permanently to the control of one quadrilateral.
  - Each driving position has two carriages command interfaces, configurable depending on the location of the carriages (present on/absent from quadrilateral). These interfaces should allow the carriages to be moved to and from the maintenance or garage zones.
  - Each driving position has:
    - One or more video screens.
    - A supervisor's screen.
  - For maintenance operations, using a remote control (radio controlled push button control-box) from within the NSC.

- The liaison between the fixed and mobile equipment can be achieved in various manners:
  - Radio transmission.
  - Infrared transmission.
  - Carrier wave transmission along the supply rails.
  - Wave guide transmission.
  - Laser transmission.

- The "radio remote control" solution is preferred for the following reasons:
  - The absence of a fixed cable connection between the mobile and static equipment.
  - The possibility of controlling several pieces of equipment simultaneously: At least two quadrilaterals and four carriages.
  - Upgradeable technical solution.

N.B.: This solution is to be validated at the detailed design stage with respect to the environmental conditions of the NSC.

In the same ways as for the electrical cabinets, the transmission/reception modules fitted to the mobile and fixed equipment within the building may eventually have to be protected against radiation (lead shielding, use of 'hardened' components or otherwise) in order to guarantee the equipment functions and reduce the maintenance interventions.

A4.10.2 Sensors/Actuators

Dependent on the equipment a set of sensors are fitted to cover zoning, security and adjustment interlocking, positioning, etc.

Nearly all of these functions are assured by commercially available limit-switch type sensors (with or without contacts), in all cases, the 'positional encoding' functions can by covered by the installation of:

- A contactless measurement system of the distance-meter type for horizontal movements, this solution keeps the coherence of the overall system architecture (no physical link between the mobile and fixed equipment).

- An encoder system fitted to the lifting machinery, to determine the height of the load.

A4.11 Monitoring and supervision systems

The carriages and quadrilaterals are controlled in normal operating mode from the control room, using:

- Video images, supplied by a monitoring system consisting of cameras, located on the quadrilaterals (2 cameras per quadrilateral), on the carriages (3 cameras per carriage) and near the tools (3 cameras for the mobile tool platform).

- The transmission of these images to the control room, as well as the transmission of commands to the cameras is to be carried out using radio transmission.

- The supervision screens give a real-time display of the status of the systems in question (animation of mobile equipment, status of the various sensors).

A4.12 Complementary backup systems

In case of a major failure, the system allows the following:

- The translation and directional movement motors are able to complete the displacement after failure. (Slight maintenance before to restart the system is acceptable).

- Carriages are equipped with 2 lifting cables knowing that only one cable is enough to lift the load.

- When using the protective box for personnel transportation, a back-up device will energize the secured carriage with 75 kW to allow the lift of the protective box in case of lost of normal electrical power supply.

The following table summarizes the main equipment failures that could happen during these activities, and presents the associated preventive and recovery measures.

Table A4. List of failures and associated protection/prevention means

TRANSPORTATION EQUIPMENT	FAILURE	PREVENTIVE AND/OR RECOVERY MEASURES
Quadrilateral	Quadrilateral blocked in position	Periodic preventive maintenance of the main crane and specific inspection/test before heavy lifting operations. Due to moto-reducer redundancy, translations remain possible after failure of one of them.
Carriage	Carriage blocked in position	Periodic preventive maintenance of the carriages and specific inspection/test before heavy lifting operations. Due to moto-reducer redundancy, directional movement remains possible after failure of one of them.
Carriage lifting motor	Hook blocked in position	Periodic preventive maintenance of the lifting motors and specific inspection/test before heavy lifting operations Manual possibility to lay down the element to a safe position.
Lifting cables and hooks	Rupture of cable or hook	Periodic inspection of the hooks and cables for defects or need of repair.

A4.13 Maintenance

A4.13.1 Maintenance Philosophy

The maintenance philosophy to be implemented must comply with:

- Operating check up of cranes equipment before every operation campaign.
- Periodical deep control every 10 years.
- Replacement of electrical devices after 20 years of operation to keep the availability level of the cranes.
- Replacement of mechanical devices after 30 years of operation to keep the availability level of the cranes.
- Verification and adaptation of the supporting structure after 50 years of operation.

An operating manual shall detail the maintenance activities.

A4.13.2 Reliability / Availability

The following reliability requirements will be applied to the Design. The above values are reliability targets to be reached by the Supplier.

Load drop hazard

- Secured lifting carriage: Risk of load drop ≤ 10^{-6} occurrence/hour.
- Classic lifting carriage: Risk of load drop ≤ 10^{-4} occurrence/hour.
- Carriage equipped with mobile tool platform: **Risk of load drop ≤ 10^{-5} occurrence/hour.**

Definitions:

Major Failure is a failure which requires the piece of equipment to be in safe area (garage or parking) to be repaired.

Minor failure is a failure which can be repaired in situ.

For the quadrilaterals:

The quantities of major failures shall not exceed 10 per year and of minor failures shall not exceed 20 per year.

For the classic carriages:

The quantities of major failures shall not exceed 10 per year and of minor failures shall not exceed 20 per year.

For the specific carriage:

The quantities of major failures shall not exceed 10 per year and of minor failures shall not exceed 20 per year.

For the carriage with the mobile tool platform:

The quantities of major failures shall not exceed 10 per year and of minor failures shall not exceed 20 per year.

Except for scheduled maintenance, the durations of intervention for repair are under the responsibility of Operation Department.

Preventive maintenance, operating and maintenance procedures will be detailed to optimize systems reliability and availability.

A4.13.3 Garages/service area

A carriage service area is provided at the north west of the NSC building. This zone is at the quadrilateral altitude, in order to be able to transfer the carriages. It includes:

- A hoist in the upper section to handle the main carriage components in the event of a disassembly (lifting gearbox, motor, etc…).

- A rack, with access to the personnel, for the storage of maintenance tools (drill, jaw crusher, etc…).

- Equipment for decontamination, particularly for the mobile tool platform.
- Access to the carriage for the personnel.

The maintenance garage allows two positions for one carriage:

- A location for maintenance/decontamination of the mobile platform lift tool: at this location the entire tool may be extended to its full length (level 35m) and operator can access to the mobile tool platform using a suspended platform.
- A location for maintenance of the carriage, the mobile tool platform and its equipment. Tools or carriage elements may be disconnected and released in the initial treatment area from this maintenance station.

Maintenance of any carriage may be performed in the maintenance garage.

Maintenance of a quadrilateral is performed when the quadrilateral is placed as near as possible to the NSC western wall. For heavy maintenance or repair of the beams, the quadrilateral can be taken down with a special device (out of scope) to be designed in detailed engineering.

A4.13.4 Storage garage

Carriages can be stored when they are not used or when they prevent another operation.

A4.14 Personnel access to the main cranes

Different access means are provided for personnel.

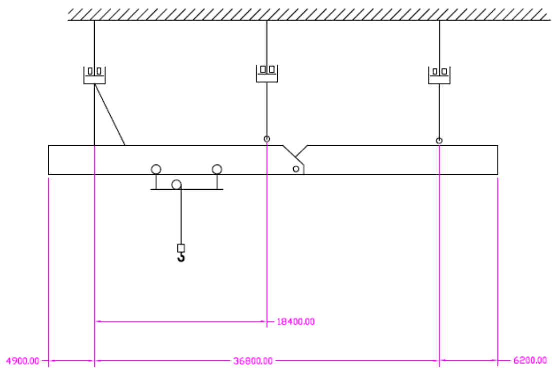
- Use of the 1-ton lift up to level +64.24 m.
- Stairway inside the arch structure from level +64.24 m to +70.02 m and 78.69m for access to maintenance garage.
- A West-East footbridge along the supporting structures of the Northern main cranes system for maintenance and for access to the quadrilateral beams and its local control panel. Access to the quadrilateral beams is strictly regulated and happens on the western side of the NSC only. Such access is designed for exceptional case of work on the crane run ways and is design to support temporary and partial shielding for radiological protection of workers. The preliminary evaluation of the maximum weight of the shielding to be taken into account in the design is 300kg/m of the pathway.
- A footbridge along the NSC western wall, at level +81.44 m, for passage from Northern West-East footbridge to Southern one and vice versa.
- A West-East footbridge along the supporting structures of the Southern main cranes system for maintenance or for access to the quadrilateral beams and its local control panel, and access for the storage garage.

A4.15 Current status of the Cranes Design

The following conceptual sketches show the base cases and alternates.

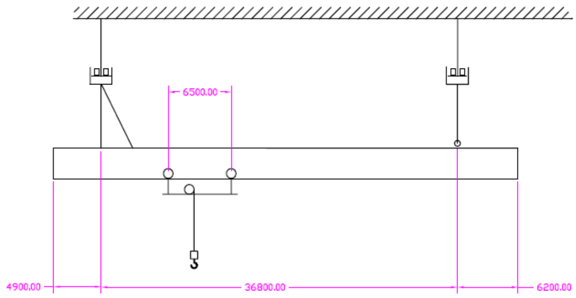
A4.15.1 Bridges

Underslung Bridge with 2 spans



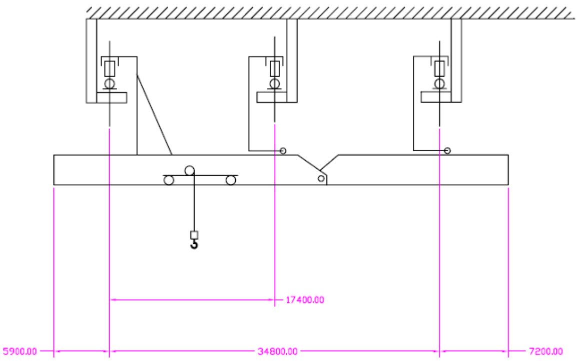
Bridge suspended by tracks.
Double span system is articulated by a pivot pin at the middle of the bridge. There are two pivot legs at the extremity rails, a rigid leg on the middle. Cantilevers are equals.

Underslung Bridge with one span



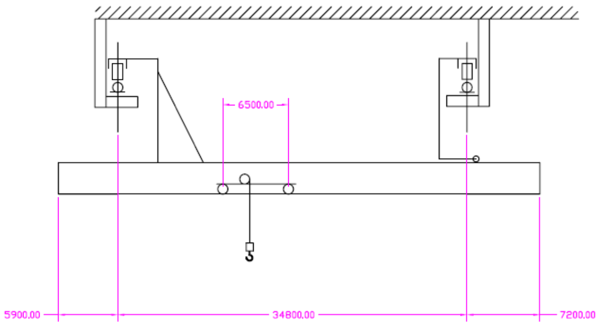
Bridge suspended by tracks.
There are one pivot leg and one rigid leg. Rigid leg infers a smaller deflection during trolley transfer. Cantilevers are equals.

Supported Bridge with 2 spans



Bridge supported by rails on L beams.
Double span system is articulated by a pivot pin at the middle of the bridge. There are two pivot legs at the extremity rails, a rigid leg on the middle. Cantilevers are equals.

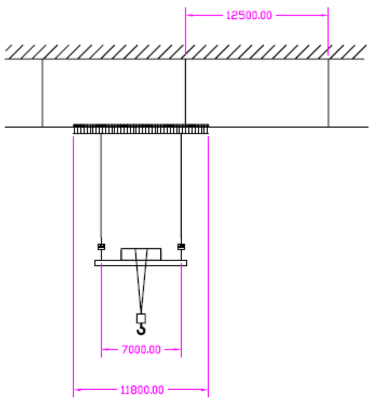
Supported Bridge with one span



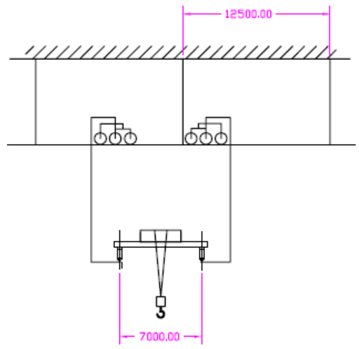
Bridge supported by rails on L beams.
There are one pivot leg and one rigid leg. Rigid leg infers a smaller deflection during trolley transfer. Cantilevers are equals.

A4.15.2 Classic trolleys

Underslung Trolley



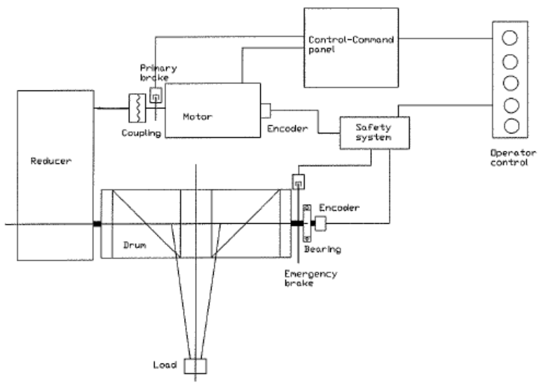
Supported Trolley



Trolley suspended by tracks.
1 drum_2 ropes

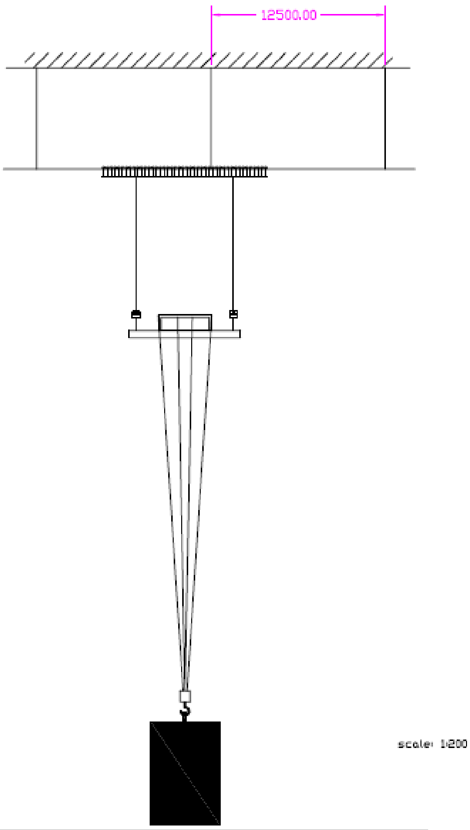
Trolley supported by rails.
1 drum_2 ropes

Classic carriage:
serie drivetrain, 1 emergency brake, 2 ropes



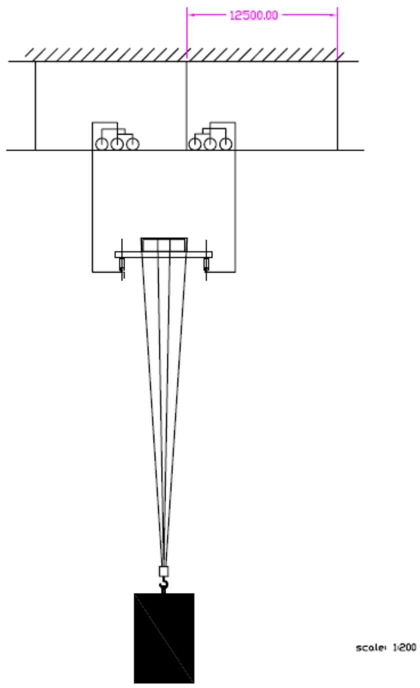
A4.15.3 Specific trolleys for the protective box

Underslung Trolley



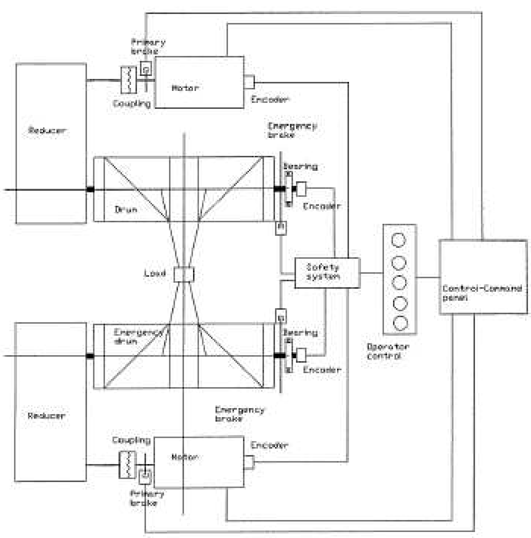
Trolley suspended by tracks.
2 drums - 2 ropes

Supported Trolley



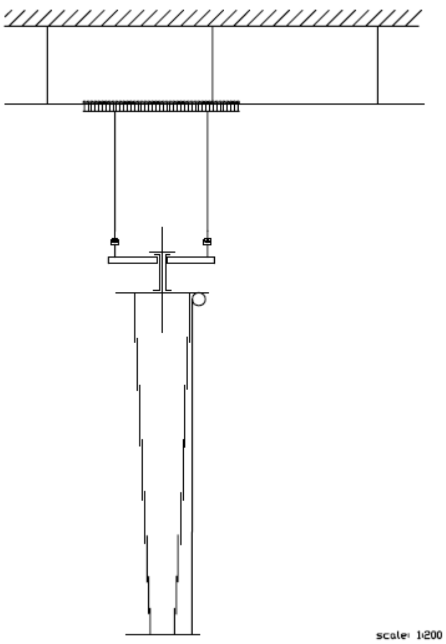
Trolley supported by rails.
2 drums - 2 ropes

Specific carriage:
serie drivetrain, 2 emergency brakes,
2 ropes, 2 drums

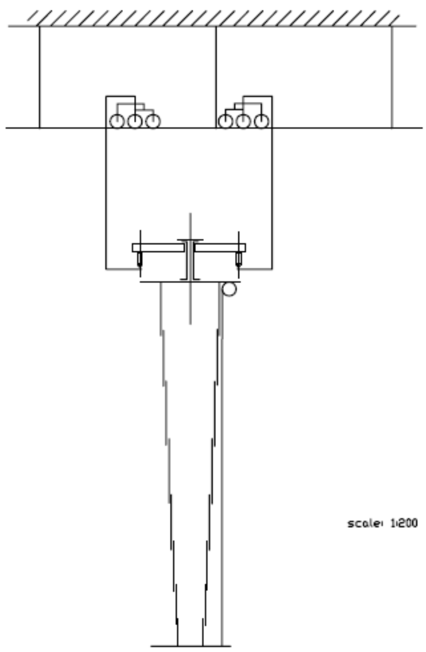


A4.15.4 Trolleys with mobile platform lift tool (Telescopic Mast)

Underslung Trolley



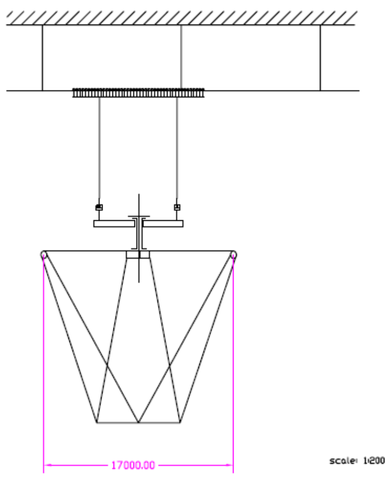
Supported Trolley



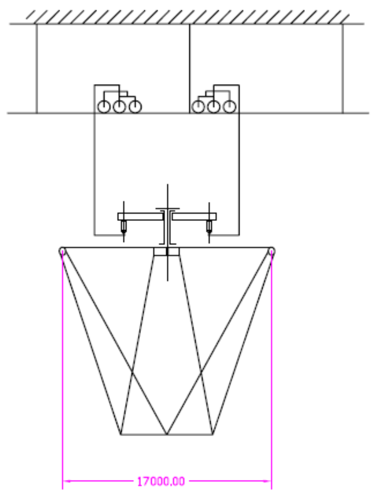
Underslung Trolley	Supported Trolley
Trolley suspended by tracks. The mobile platform lift tool with a seven moving tube telescopic assembly is suspended. A pivot allows rotation of the mast on the trolley platform.	Trolley supported by rails. The mobile platform lift tool with a seven moving tube telescopic assembly is suspended. A pivot allows rotation of the mast on the trolley platform.

A4.15.5 Alternate to trolleys with mobile tool platform

Underslung Trolley



Supported Trolley



Trolley suspended by tracks.
The mobile platform lift tool with tension truss system is suspended.

Lower platform is directed by 6 ropes.

A pivot allows rotation of the TT on the trolley platform.

Trolley supported by rails.

The mobile platform lift tool with tension truss system is suspended.
Lower platform is directed by 6 ropes.

A pivot allows rotation of the TT on the trolley platform.

A5 VENTILATION, GAS PURIFICATION & AIR CONDITIONING SYSTEMS

A5.1 Introduction

Attachment 03 has made it clear that main functions of these Systems (Ventilation, Gas purification & Air conditioning) are to:

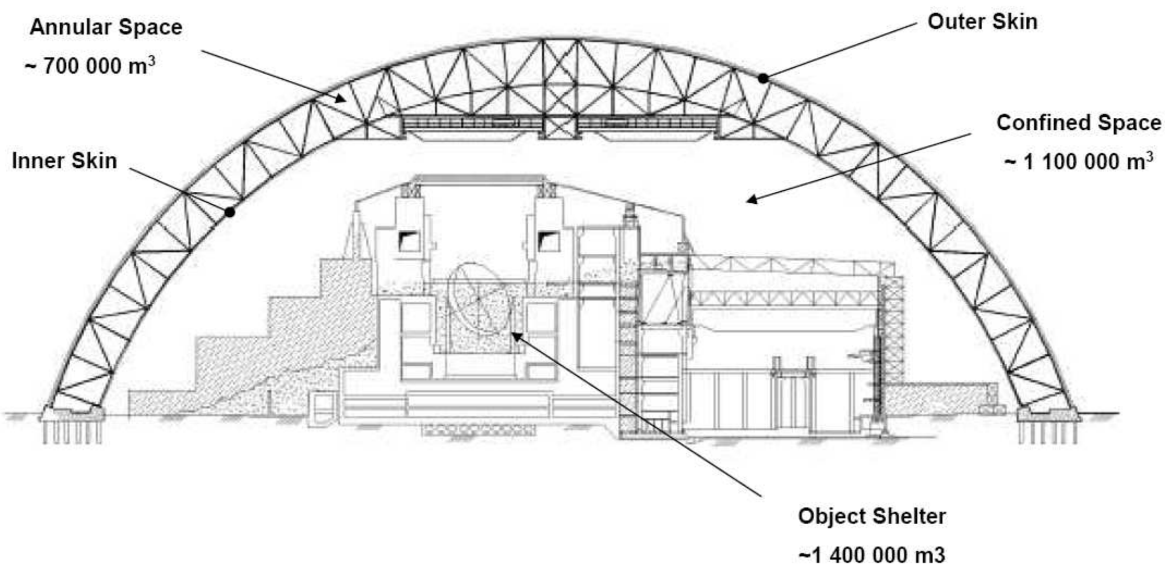
1) Confine contamination by assuring that airflow is always from areas of lower potential for contamination towards areas of higher potential for contamination;
2) Maintain the emissions to the environment within limits prescribed by regulations;
3) Provide a controlled environment (temperature, humidity and cleanliness) for personnel comfort and safety;
4) Prevent the spread of smoke and products of combustion in the event of a fire;
5) Prevent generation of flammable and explosive vapours, gases and dust mixtures in excess of established values.

A5.2 Design package Organisation

To make it easier to organise the Design stage, studies of these Systems are split into five parts:

1) Ventilation of the annular space of the arch and pinions East and West (about 700 000 m^3);
2) Ventilation of confined space (about 1 100 000 m^3);
3) Sealing of confined space;
4) Ventilation and smoke exhaust of the working areas and auxiliary facilities;
5) Smoke exhaust of confined space.

The confined space is the "free volume" under the arch.



This volume is the total volume under the arch (2 500 000 m^3) minus the volume occupied by the Object Shelter (1 400 000 m^3).

Design takes into account the following dependant constraints:
- Nuclear safety;
- Seismicity of the site;
- Climatology (climatic and weather phenomena) and freeze hazard analysis;
- Thermal stresses and more particularly the phenomena of heat transfer per radiation (thermal radiation effect during night and day);
- Safety and protection of the workers and particular conditions related to the site.

Energy saving and environmental protection are also priority.

A5.3 Main normative documents

The main normative documents applicable to "Ventilation, Gas purification & Air conditioning Systems" at the Design stage are:
- OSPU-2005 – "Basic Sanitary Rules for Radiation Safety of Ukraine", approved by the Ministry of Health of Ukraine (MHU) and entered into force 20 May 2005, **items 12.2.1 to 12.2.26**,
- SPAS-88 – "Health and Safety Rules for Design and Operation of Nuclear Power Plants" (Russian), revised by MHU and State Nuclear Regulatory Committee of Ukraine (SNRCU), Order № 196/59 dated 06 May 2003, **items 10.2 to 10.50**,
- NRBU-97 – "Radiation Safety Standards of Ukraine", 1997.

SNIP 2.04.05-91 U – "Building Regulations – Heating, Ventilation & Conditioning" approved by the State Committee of Ukraine on Town Planning and Architecture by Order No. 117 of the 27th June 1996. do not apply to design of heating, ventilation and conditioning of shelters and constructions meant for works with radioactive substances, sources of ionizing radiation, objects of underground mining and the rooms in which explosives are manufactured, stored or used.

In the event of need and for auxiliary buildings only, the French publication "Guide de ventilation des installations nucléaires - deuxième édition – Juillet 1987" of the CETREVE (Centre technique de Reférence en Ventilation et Epuration) and the European standard ISO 17873 "Nuclear facilities – Criteria for the design and operation of ventilation systems for nuclear installations other than nuclear reactors" will be able to supplement this main normative documents.

A5.4 Objectives of the Ventilation, Gas purification & Air conditioning Systems

Performance criteria of the systems equipping the NSC are:
- No condensation inside the annular space;
- No condensation on inner skin of arch;
- To prevent the migration of the radioactive dusts by maintaining an airflow from outside to inside the arch;
- To maintain conditions of an environment acceptable for the personnel working in this space (radiological level, temperature at ground level, temperature at main crane level);
- To maintain the confined space in depression compared to the atmospheric pressure in order to minimize leakage rate towards outside (release at ground level).

A5.5 Ventilation of the annular space

The ventilation of the annular space has to achieve the following objectives:

- Hygrometry control to avoid steel arch and cladding corrosion;
- Uniform temperature (very low gradient of temperature) on the internal face annular space (inner skin) above dew point of the confined space to prevent condensation.

To realise these objectives, the annular space (~700 000 m^3) is compartmented in a series of cabins (see

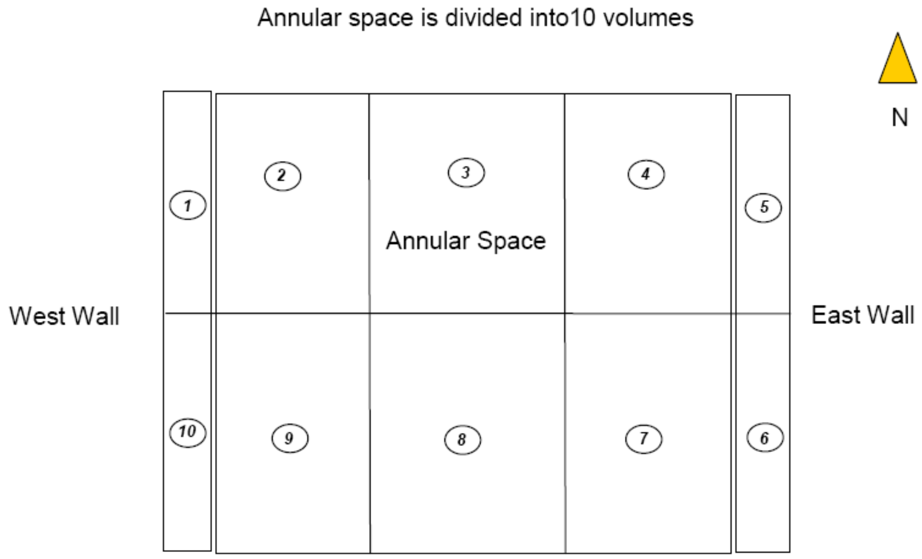


Figure A10 **Zoning**).

This partitioning makes it possible to isolate from a thermal level the northern size from the southern face.

It is the same principle allows to the East wall and the West wall.

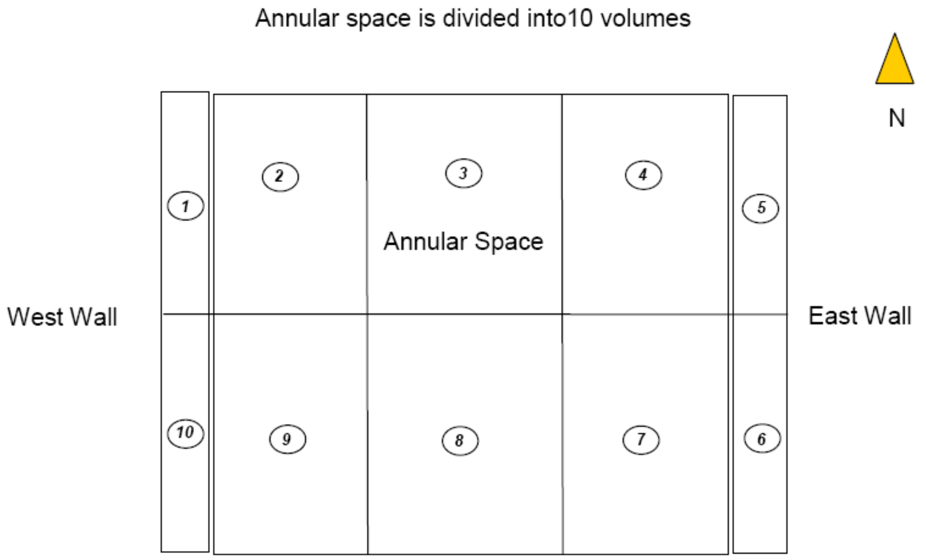


Figure A10 Zoning

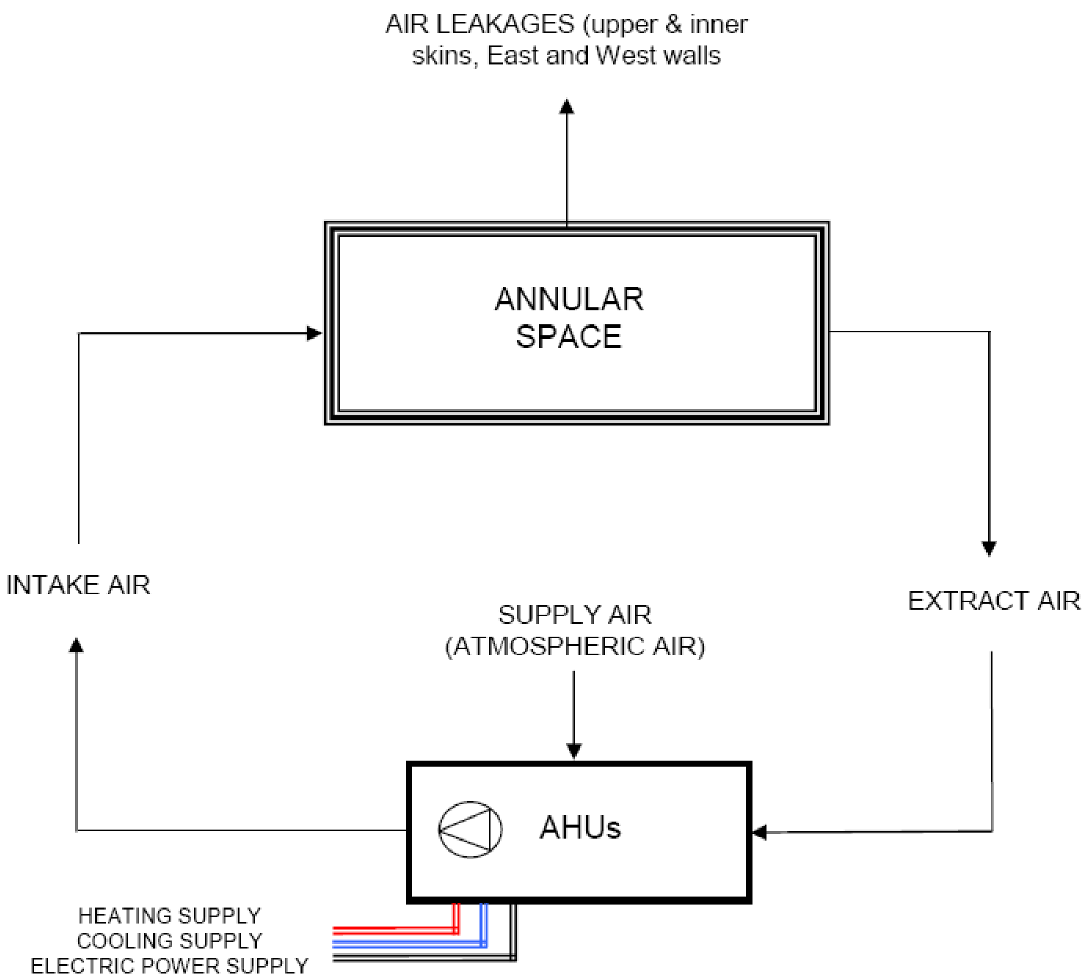


Figure A11 Ventilation per volume of the annular space

The principle selected (see

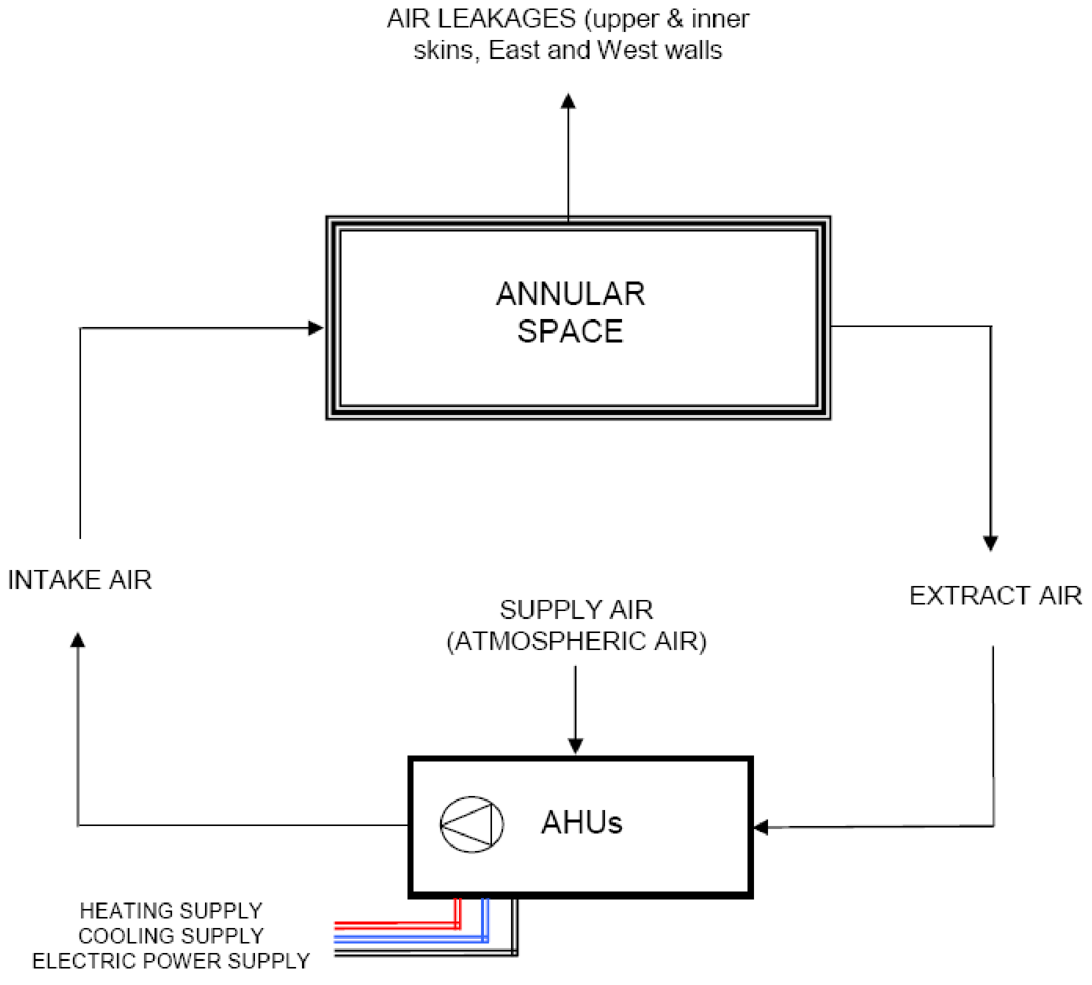


Figure A11 Ventilation per volume of the annular space) is to:

- Input and extract (recycling) air conditioning (heating and/or cooling) in each volume of the annular space through ductworks and air handling units (AHU's);
- Maintain the annular space with a pressure higher than the atmospheric pressure.

The intake air (atmospheric air) introduced into the recycling circuit compensates for leaking.

The pressure level inside the annular space is not determined at the stage of Design.

For calculation of the cladding, the difference in pressure between annular space and confined space will be between 20 and 150 Pa. This value will be defined and justified at the Design stage.

Overpressure prevents migration of the radioactive dusts towards annular space.

At the Design stage, a detailed NSC thermal balance analysis will be developed considering the thermal properties of the structure and Shelter including Arch thermal insulation, all thermal physics parameters of the Object Shelter and local climatic data.

Thermal performances of the arch (confined space and annular space) will be simulated by Computational Fluid Dynamics (CFD) software (AIRPAK, a product of ANSYS Inc. Corporate).

This 3D simulation will be used to optimize solutions for:

- Airflow rates, size of the AHUs and ductworks;
- Cooling, heating & electrical power supplies;
- Temperature and hygrometry levels in the annular space for extreme conditions (winter & summer);
- Temperature and hygrometry levels in the annular space in transient state (spring & autumn).

The difficulties of access inside annular space (geometry, increased radioactivity) impose on the ductworks the implementation of:

- Materials of high quality (stainless steel or other);
- Adapted duct fixings (mechanical vibrations & seismic controls), grids, diffusers, registers.

The concept of "low maintenance" (no components replacement during its lifespan) will be developed in this phase of design for integrated systems in the annular space.

A5.6 Ventilation of the confined space

Ventilation of the confined space has to ensure that:

- the airflow direction is maintained from areas of lower radiological contamination to areas of potentially higher radiological contamination,
- the conditions of environment acceptable for the personnel working in this space is maintained (radiological level, temperature),
- there is no condensation on inner skin of arch,

Ventilation air will be supplied and distributed (intake air) at the bottom of the arch and collected at the top of the arch before it is exhausted (extract air).

A5.6.1 Extract airflow rate

Volume of air extracted under the arch ensures that airborne particulate level conforms to the requirements of the document "NCS Acceptable Design Level" (see Appendix 1 "Specifications" – Attachment A58.1).

The main design criteria defined in the Contract documents are:

- The release limit (see Attachment 58.1 – Table 1 - Release Limit options);
- The maximum airborne concentration must allow for permanent attendance of personnel performing category III works at workplaces of category 2 (see Attachment 58.1). It must thus be limited to 210 Bq/m^3 for β emitters (Attachment 00).

The control of condensation is not a determining factor for the rate of extracted air.

The air exchange rate inside the arch is fixed at 200 000 m^3/h. At this Design stage, the leakage rate from the annular space is estimated at 21 000 m^3/h.

The flow rate inside the Arch is thus around Q = 179 000 m^3/h.

These values are provisional and will be confirmed at the Design stage.

A5.6.2 Treatment of the extract air (filtration)

A statistical assessment has been made based on measurements of the Object Shelter releases.

It shows that, providing some margin, the daily release from the Shelter is circa 10 MBq/day, 310 MBq/month.

This daily release rate is much lower than the release limits defined in the table below (except for low release in option 2 which will not be considered as well).

Table A5 Release Limit options

Option	1	2	3	4	5	6
RL_H, MBq/month	4900	4500	4000	3500	3000	2500
RL_L, MBq/month	0	190	450	700	800	810

If the airborne contamination within the NSC remains limited to 210 Bq/m^3, the monthly release would equate:

R = 210 Bq/m^3 × 200 000 m3/h × 24 hours/day × 31 days/month = 31 248 MBq/month

Which is several times the high release limits whichever the chosen option.

Therefore, considering a monthly average airborne contamination of 210 Bq/m^3, air filtration before exhaust will be required in order to meet the release criterion and, therefore, filtration will be safety important.

Filtration costs for such a flow rate are rather high because of their purchase and operational management and because of their further management as radioactive waste.

From this point of view, they should be avoided as far as achievable. For this, another criterion should be developed.

The following table shows the airborne contamination inside the NSC for different values of assumed release from the CS-2 operations.

Table A6 Airborne contamination within the NSC for various CS-2 releases

Monthly release from CS-2 workplaces and auxiliary facilities (MBq/month)	4576	4176	3676	3176	2676	2176

Monthly release from the Shelter (MBq/month)	310	310	310	310	310	310
Monthly release from the turbine hall (MBq/month)	14	14	14	14	14	14
Total release (MBq/month)	**4900**	**4500**	**4000**	**3500**	**3000**	**2500**
Targeted option for high release limit	1	2	3	4	5	6
Corresponding monthly average airborne contamination inside the NSC (Bq/m^3)	33	30	27	24	20	17

From the above table, it can be noted that the contamination criterion (210 Bq/m^3) is always met whichever the targeted release limit option.

Permanent attendance of personnel in the NSC is thus allowed.

Concerning the low releases, they will be avoided in normal operation providing engineering features to be defined at the Design stage.

The selection of the release option will be made at the Design stage depending on the technical simplicity of the systems limiting the low level release in normal and abnormal operation conditions.

Preliminary, option 5 can be chosen because it provides a sound compromise between low and high release limits.

Specific studies might be carried out at the Design stage in order to opt for lower release limit options.

This will provide for more margins and thus flexibility to the CS-2 Contractor.

The average airborne contamination will be measured permanently inside the NSC to check deviations from the criteria.

Moreover, an in-line contamination monitoring system will be implemented at the exhaust of the ventilation system before the release stack.

Upon exceeding a set contamination threshold (abnormal operation condition), this monitoring system will trigger a general alarm and will initiate a general mitigation procedure consisting of the following actions:

- Automatic stop of the ventilation system of the confined space;
- Compensate leaks coming from the annular space with an emergency extract air system associated with nuclear filtration system (HEPA one stage);
- Keep the Arch in a safe configuration. The provisions ensuring this passive safety will be defined at the Design stage.

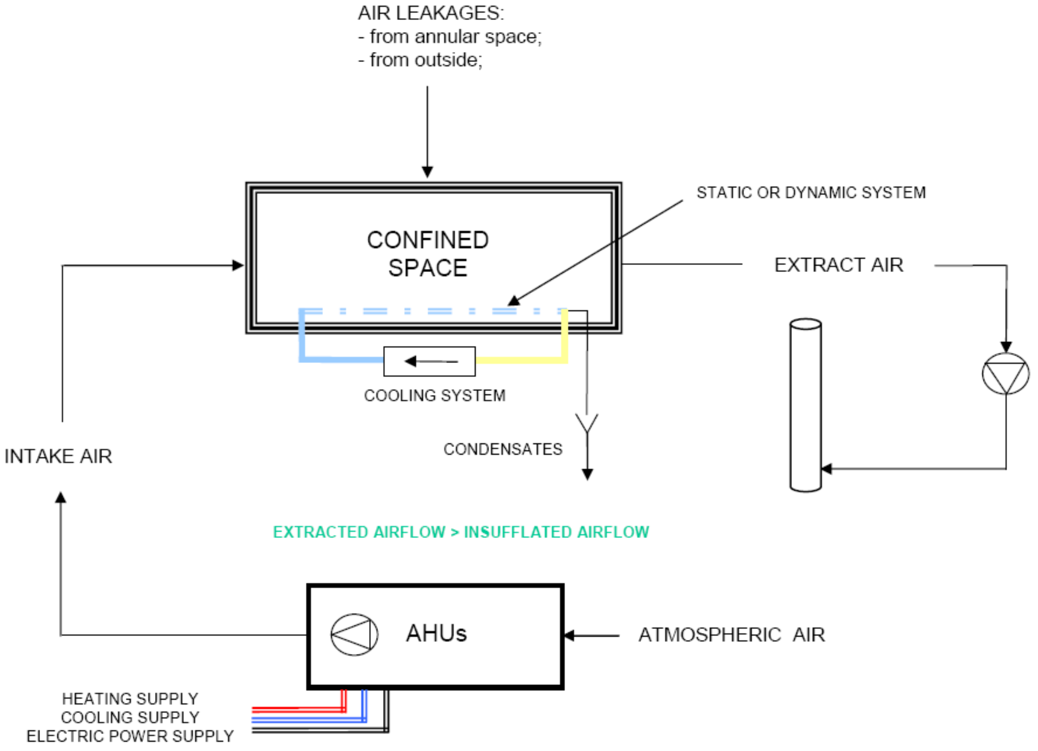
All systems added to ensure this mitigation procedure are considered important to safety (SSC IS-2). The mitigation procedure will be kept ongoing long enough to allow for dust settling.

The ventilation system of the confined space will be restarted manually to a normal flow condition once the airborne contamination in the NSC returns to a level that allows compliance with the high release limits.

This level will be defined at the Design stage.

It can be concluded that the confined space will be equipped with:

- A normal extract ventilation system (flow rate: 200 000 m^3/h) without filtration functioning under a determined contamination threshold (see



-
- Figure A12 "Normal" ventilation of the confined space);
- An emergency extract ventilation system including nuclear filtration (HEPA one stage), which will keep accidental releases within acceptable limits (see **Figure A13 "Emergency" ventilation of the confined space**). The flow rate of this emergency ventilation system will be determined at the Design stage (flow rate > 21 000 m^3/h).

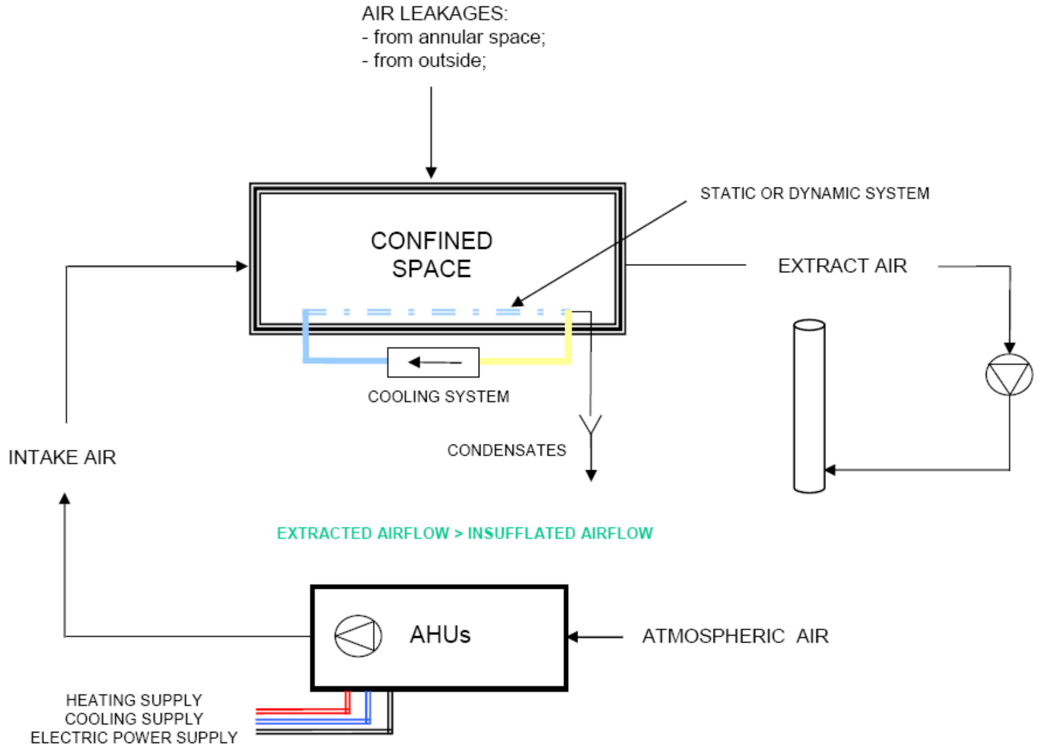


Figure A12 "Normal" ventilation of the confined space

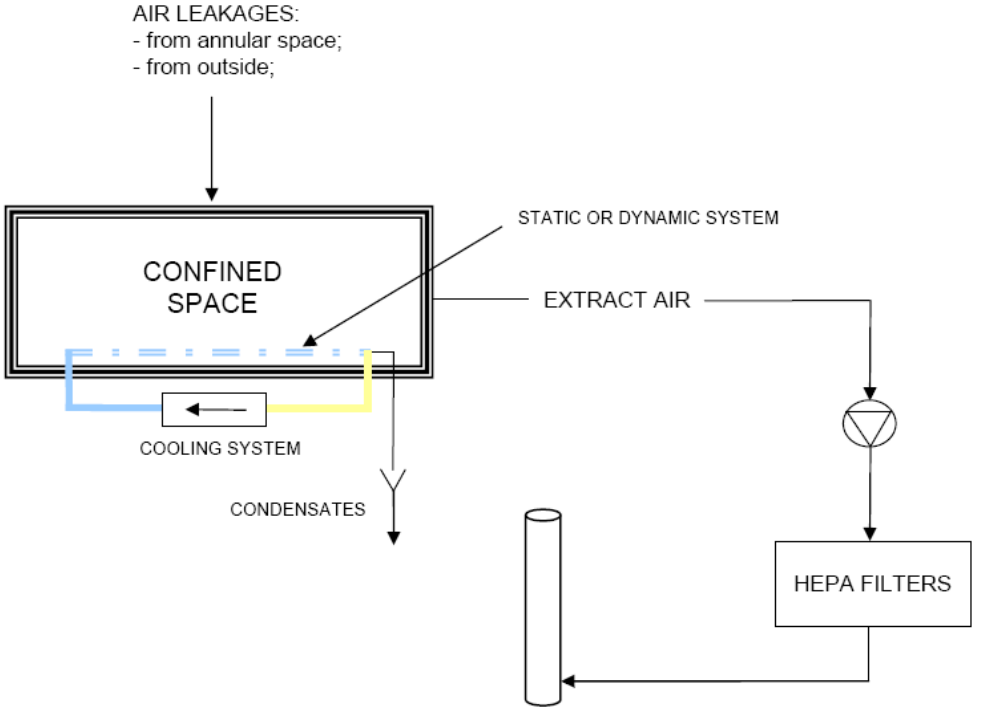


Figure A13 "Emergency" ventilation of the confined space

As a design basis and in order to evaluate operation costs, release limit option 5 can be chosen.

Further studies will help to allow for using a release limit option less constraining for the CS-2 Contractor.

This option can be summarised as follows:

Table A7 Retained release limit option

Monthly high release limit	3000 MBq/month
Monthly low release limit	800 MBq/month
Monthly allowable release from dismantling operations and auxiliary facilities (**Design Criterion for CS-2 Contractor)**	2676 MBq/month
Corresponding monthly average airborne contamination inside the NSC	20 Bq/m^3

A5.6.3 Intake airflow rate

The intake airflow introduced into confined space will be always lower than the exhaust airflow in order to:

- Maintain in the confined space an airflow from outside to inside the arch;
- Minimize leakage rate (west wall & east wall).

The intake air system is correlated with the normal extraction system (see

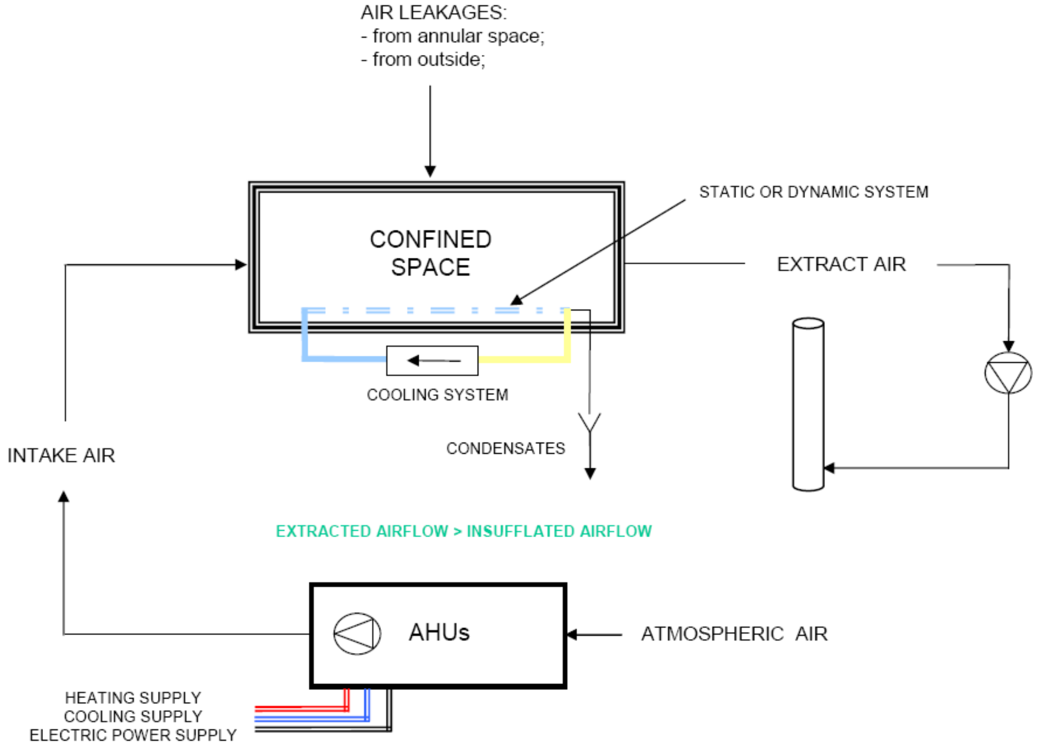


Figure A12 "Normal" ventilation of the confined space).

During the "winter period", the intake airflow can be preheated. This pre-heating can improve balance of the heat balance of annular space. The hygrometry can be also controlled.

Calculations and simulation by CFD software will have to show the correlation between the two systems of air treatment (annular space and confined space).

A5.7 Ventilation ductwork

The ventilation ductwork for the annular space and confined space will be designed to limit the maximum velocity to no more 10 m/s in ducts that carry to no more than 34 000 m^3/h.

To avoid dust deposits inside the ducts, minimal speed will be higher than 7m/s.

Smaller ducts will be sized to maintain the friction losses fewer than 80 Pa/100 m.

Ducts are circular and assembled by welding. The compensation of expansion will be ensured by "lyres - Ω".

In the confined space, the airflow velocity at the diffusers level is lower than 1 m/s (protection against dust lifting).

A5.8 Ventilation airflow requirements and major equipment list

Table A8 Ventilation airflow requirements

Description	Radioactive contamination	Required Airflow (m^3/h)	Air pressure (Pa)	Temperature	Hygrometry
Annular space	Clean	Determinate by modelling	20-150	controlled	controlled
Confined space	Contaminated	200 000	≤ Atm press.	conditioned	conditioned
Auxiliary buildings	Clean / Contaminated	Determinate at the Design stage		controlled	controlled

Table A9 Ventilation major equipment list

Area served	Equipment	Number	Minimum capacity (%)	Adjustment (%)	Location
Confined space	Normal Blower	2	66	50	Ventilation building
	AHUs	1	120	-	
	Normal Extract fan	2	66	0 to 50	
	Emergency Extract fan	2	2	100	
	Nuclear filtration units	4	133	-	
Annular space	AHUs	10	10	120	External
Auxiliary buildings	Determinate at the Design stage				Ventilation building

The values given in these two tables are indicative. The safety analysis will make it possible to refine these values at the design stage.

A5.9 Management of the conditions of environment in confined space

A static or dynamic system will come to supplement the equipment implemented (see

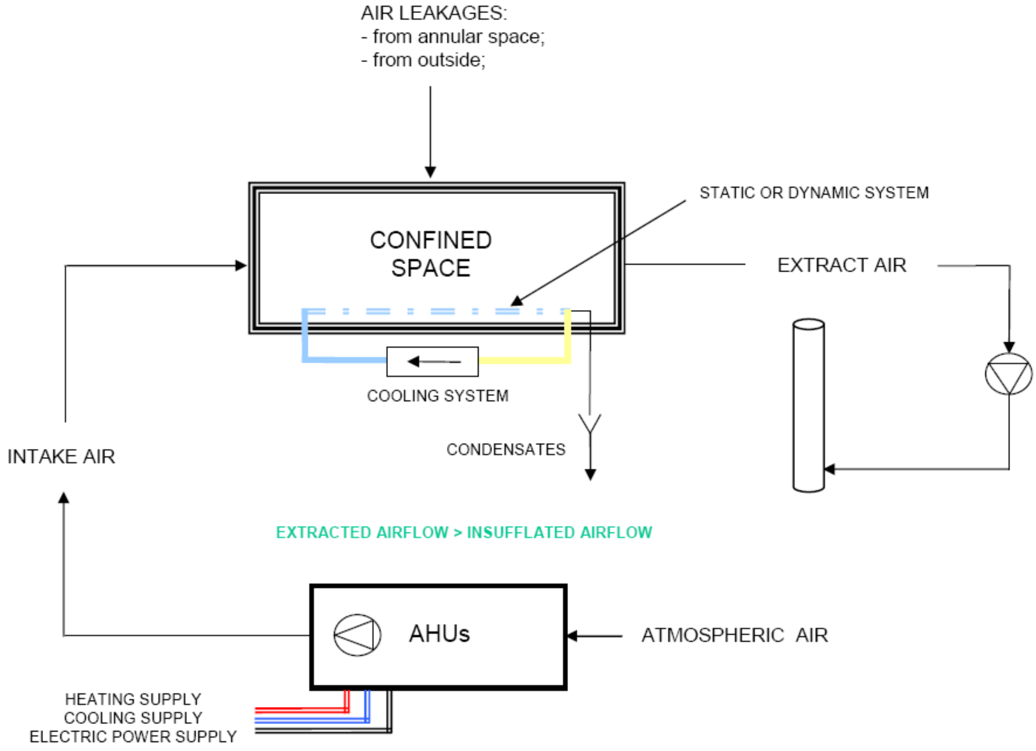


Figure A12 "Normal" ventilation of the confined space).

For example, this system will be of the type "finned tubes" with circulation of fluid (concept of low maintenance).

In summer period, the cooling water circulation in the tubes will allow:

- A degree of hygrometry to be maintained that is acceptable and within the fixed limits (forced condensation);
- The increase of temperature to be limited inside the confined space.

The flexibility of this system will make it possible to manage the transitional stage (period ranging between the cover of the shelter and thermal stabilization (hygrometry, temperature).

This transitional period can be estimated at several years.

This system will be developed at the Design stage

Calculations and simulation by CFD software will have to show the correlation between this system and the two systems of air treatment (annular space and confined space - normal ventilation).

A5.10 Sealing of the confined space

By "sealing", it is agreed that there is no migration of radioactive dusts apart from within the confined space.

This migration is possible at the connections between the arch pinions and the existing buildings.

The sealing of these connections will be of two types:

- on internal and external faces of the West wall and East wall, a mechanical connection integrated into the cladding,
- on external face, a dynamic connection by curtain of air and/or a modulation of the airflow extracted according to a variation between the pressure in the confined space and the outside of the arch

This second solution will be developed at the Design stage, if necessary.

A5.11 Ventilation and smoke exhaust of the working areas and auxiliary facilities

These systems will be studied and developed at the Design stage, in compliance with the Ukrainian norms and standards that apply to this category of nuclear buildings.

A5.12 Smoke exhaust of confined space

This concept will be developed at the Design stage.

A5.13 Ventilation performance criteria

A5.13.1 Quality

NOVARKA guarantees that the whole of HVAC supplies is of highly professional quality. The components and the matters are selected as such and used with sufficiently wide tolerances of working.

The elements and the components of HVAC systems are of "proved" type. Materials will not be considered that do not already have a proven reliability in similar installations and situations.

A5.13.2 Identification and evaluation of damages and incidents

Equipment failures affecting the availability and reliability present more or less important risks of disturbance in the exploitation of the HVAC systems.

Consequences of these failures result in equipment unavailability, which can result in stopping operation of the HVAC systems by safety measures.

Three classes of damages are distinguished:

- Minor damages;
- Significant damages;
- Critical damages.

A5.13.2.1 Minor damages

A minor damage is an equipment failure that does not have a consequence on its use but which involves an intervention of corrective maintenance.

A5.13.2.2 Significant damages

A significant damage causes the HVAC system to be stopped without consequence on the level of safety.

It asks for an intervention of corrective maintenance.

A5.13.2.3 Critical damages

A critical damage involves disturbance of the HVAC systems potentially generating important risks (freezing, fire, contamination).

It involves an intervention of immediate corrective maintenance and safety measures.

A5.13.3 Indicators of performance

HVAC systems are ready to carry out tasks under definite conditions.

The purpose of the method criteria evaluation of RAMS - **Reliability, Availability, Maintainability and Safety** (Safety & Security analysis) of the installation is to characterize this aptitude.

A5.13.3.1 Reliability

In general, reliability (systemic def.) is the ability of a person or system to perform and maintain its functions in routine circumstances, as well as hostile or unexpected circumstances or the ability of a system or component to perform its required functions under stated conditions for a specified period of time."

Reliability is expressed in the number of failures that occur (failures of any nature) by equipment and by month.

Reliability assures that the HVAC systems great using constancy under given conditions (weak frequency of failures). The reliability selected is indicated in the following table.

Table A10 Reliability

Equipment	**Reliability (failure by equipment by month)**
AHUs (annular space)	0.5
AHUs (confined space) & Normal blower	0.5

Normal extract fan	0.5
Emergency extract fan	0.2
Nuclear Filtration	0.2
Dampers	0.2

The values given in this table are indicative. The safety analysis will make it possible to refine these values at the Design stage.

A5.13.3.2 Availability

Availability is the ratio of time a system or component is functional to the total time it is required or expected to function.

This aptitude is function of a combination of reliability, maintainability and logistics of maintenance of the system.

The availability is measured by the probability that an entity achieves its operation requirement at a given moment.

For a consumable system, the concepts of reliability and availability are identical.

The index of availability is calculated according to the formula:

$$Ai = MTBF / (MTBF+MTTR)$$

If mean time between failures (MTBF) or mean time to failure (MTTF) is very large compared to the mean time to repair (MTTR) or mean time to replace (MTTR), then you a high availability will result.

Likewise, if mean time to repair or replace is low, then availability will be high.

As reliability decreases (i.e., MTTF becomes smaller), better maintainability (i.e., shorter MTTR) is needed to achieve the same availability.

Of course, as reliability increases then maintainability is not so important to achieve the same availability. Thus tradeoffs can be made between reliability and amenability to achieve the same availability and thus the two disciplines must work hand-in-hand to achieve the objectives.

Ai is the largest availability value you can observe if you never had any system abuses.

Considering the operational availability equation, operational availability looks at availability by collecting all of the abuses in a practical system

$$Ao = MTBM / (MTBM+MDT).$$

The mean time between maintenance (MTBM) includes all corrective and preventive actions (compared to MTBF which only accounts for failures).

The mean down time (MDT) includes all time associated with the system being down for corrective maintenance (CM) including delays (compared to MTTR which only addresses repair time) including self-imposed downtime for preventive maintenance (PM) although it is preferred to perform most PM actions while the equipment is operating.

The availability selected is indicated in the following table.

Table A11 Operational Availability Ao

Equipment	Ao (%)
AHUs (annular space)	90
AHUs (confined space) & Normal blower	90
Normal extract fan	90
Emergency extract fan	95
Nuclear Filtration	95
Dampers	95

The values given in this table are indicative. The safety analysis will make it possible to refine these values at the Design stage.

A5.13.3.3 Maintainability

Maintainability is defined as the probability of performing a successful repair action within a given time.

In other words, maintainability measures the ease and speed with which a system can be restored to operational status after a failure occurs.

For example, if it is said that a particular component has a 90% maintainability in one hour, this means that there is a 90% probability that the component will be repaired within an hour.

In maintainability, the principal variable is "time-to-repair", in the same manner as "time-to-failure" is the principal variable in reliability.

The only difference being that instead of times-to-failure we are using times-to-repair. What one chooses to include in the time-to-repair varies but can include:

- The time it takes to successfully diagnose the cause of the failure;
- The time it takes to procure or deliver the parts necessary to perform the repair;
- The time it takes to gain access to the failed part or parts;
- The time it takes to remove the failed components and replace them with functioning ones;
- The time involved with bringing the system back to operating status;
- The time it takes to verify that the system is functioning within specifications;
- The time associated with "closing up" a system and returning it to normal operation.

In the interest of accuracy, the parameters that are and are not included in determining the repair distribution should be documented.

The mean time to repair (MTR) which characterizes maintenance depends primarily on the design of the installations, of their technology of implementation and the organization of maintenance.

For each part of systems, MTR is fixed (see column 3 of the Table A12 Maintainability).

It is important that the detection of failures is as easy as possible and than repairs can be carried out quickly.

To this end, the disassembly capability of the various systems and the interchangeability of parts are considered.

A stock of spare parts for maintenance is envisaged by taking account the reliability of each interchangeable element.

The indicator of quality fixes the number of failures treated within the deadline (see column 4 of the Table A12 Maintainability).

Acceptability threshold is fixed (see column 2 of the Table A12 Maintainability).

Table A12 Maintainability

Equipment	Acceptability threshold (hours)	Mean time to repair (hours)	Failures treated within the deadline (%)
AHUs (annular space)	60	8	85
AHUs (confined space) & Normal blower	60	8	85
Normal extract fan	60	8	85
Emergency extract fan	48	8	90
Nuclear Filtration	24	4	95
Dampers	24	4	95

The values given in this table are indicative. The safety analysis will make it possible to refine these values at the Design stage.

A5.14.1 Safety and Security Analysis

Ventilation systems installed in the NSC and auxiliary building are among those that provide vital safety functions.

Such systems contribute to the safe environment for workers and serve a vital confinement function should work processes result in airborne releases of hazardous materials.

A5.14.1.1 Ventilation systems safety analysis

Safety analysis is an essential element of a safety assessment. It is an analytical study used to demonstrate how safety requirements are met for a broad range of operating conditions and various initiating events.

Safety analysis involves deterministic and probabilistic analyses in support of the design, commissioning and operation of the ventilation systems.

The objectives of deterministic analysis are to:

- Confirm that the design of ventilation systems meets design and safety requirements;
- Derive or confirm operational limits and conditions that are consistent with the design and safety requirements for the ventilation systems;
- Assist in establishing and validating accident management procedures and guidelines;
- Assist in demonstrating that safety objectives, which may be established to limit the risks posed by the ventilation systems, are reached.

This document identifies high-level requirements for conducting and presenting a safety analysis, taking into account best national and international practices.

This analysis will be carried out at the Design stage. The results of this analysis make it possible to define definitively the values given in Table A12 to Table A14.

A5.14.1.2 Ventilation systems security analysis

The Ventilation systems analysis security is an examination and evaluation of the various factors affecting the security of the workers (personnel of maintenance).

When a technical defect is likely to involve the deterioration of materials or expensive equipment, the concept of security for what relates to the incidence of the technical defects or the human errors can apply to material protection insofar as this material protection is not likely to be contradictory with the measures to be taken to avoid the personal injuries.

Security is obtained by:

- The implementation of materials of design and technological specification such that an unspecified defect cannot have dangerous consequence to the workers;
- The installation of control systems having the preceding qualities.

A6 TECHNICAL AREA

The purpose of the creation of a technical area is to gather the following technical equipment necessary for correct exploitation of the arch:

- Boilers (multi-fuel burners gas /fuel-oil) and heat exchanger with ChNPP hot water supply network;
- Gas regulation system (for boilers);
- Chillers;
- Generators;
- Fire water pressure boosting system and treatment;
- Drinking water suppressed system and treatment;
- Transformer room (low voltage for technical area);
- High voltage electrical room (6000 V);
- Low voltage electrical room (400 - 240 V);
- Compressed air system.

Heating plant is necessary for service continuity when the hot water supply network is out of order (maintenance, breakdown, etc).

The buildings sheltering this equipment will be supplemented by:

- Workshops & warehouse for maintenance of the equipment;
- Fuel oil tank storage (boilers & generators – capacity determined at the Design stage);
- Fire water tank (capacity determined at the Design stage);
- Drinking water tank (capacity determined at the Design stage).

This technical area will be located outside the local zone and near the various networks:

- Electrical room (transformer plan);
- Hot water supply network;
- Fire water supply network;
- Drinking water supply network.

This zone will house the existing transformer plant and will be protected (fences and guardroom for example).

In the event of a major incident (loss of the electric power, gas network or water supply networks, etc.) the technical area will be able to function in an autonomous way for a period to be defined at the Design stage.

This equipment autonomy will be assured by storage of fuel (fuel oil) and water.

Outside the local zone, the access is easier for maintenance teams.

A7 ELECTRICAL POWER SUPPLY SYSTEM

The power supply system includes:

- The electrical power supply to all NSC electrical loads (including auxiliary buildings);
- The electrical power supply to the Technical Building;
- The lighting of the inside of the NSC;
- The cable and cable-ways;
- The earthing scheme and lightning protection;
- The aircraft navigation signs.

A7.1 6kV Power supply

The power supply of the NSC comes from two independent power trains A and B:

- Two 6kV feeders, supplied by ChNPP;
- Four cells n° 107, 109, 207, 209, cabinets with inbuilt high-voltage electro-technical equipment, protection relay devices, measuring devices, automatics, alarm, account and control; all supplied by ChNPP.

Table A13 Cell properties

CHARACTERISTIC	VALUE
Nominal current	630A
Protection device disconnection current	31,5kA
Electro-dynamic stability current	80kA.

At this stage of the design, no loads larger than 200kW have been identified. Therefore, the individual loads will be powered from a 0.4kV low voltage system. If individual loads should be identified at a later stage of the project, they should be powered from a 6kV voltage system.

NOVARKA will install Diesel Generators unless the supplies of electrical power are guaranteed to be available and reliable.

A7.2 Classification of equipment

The Electrical Power Supply System design shall ensure reliable power supply to all electrical loads in accordance with their category and safety classification.

The Detailed Design shall identify all electrical loads with respect to their electrical power supply category, as defined in the Norms for Set-up of Electrical Installations (PUE), sixth edition, 1986 as follows:

- In accordance with the PUE, Section 1.2.18, the Category I loads shall be powered from two independent sources that provide backup for each other; the power outage that occurs as a result of a loss of a single power supply will last only until power is automatically restored;
- In addition to two independent power supplies required for the Category I loads, the Category I Special Group loads, defined in accordance with the PUE, Section 1.2.18, require a third

independent self-sustained source that uses an automatic transfer logic (e.g. diesel generator, DC battery, uninterruptible power supply);
- Electro-receivers of the second category are those whose power supply interruption results in mass product troubles, mass outages of workers, to violation of normal activity of rural habitants. For the electro-receivers of the second category, the power supply must come from two independent mutually reserving sources of feed. A loss of electrical power is admitted for a time necessary for repair personnel to be operative (PUE Section 1.2.20];
- Electro-receivers of the third category are fed from one source, with the condition that interruption, necessary for repair or replacement of the damaged element does not exceed 1 day (PUE Section 1.2.21).

In accordance with this classification and the safety analysis, at this time a first classification of the potential electro-receivers has been established:

Table A14. Classification of systems, structures and components according to PUE norm

Structures, systems and component	Category I Special group loads		Category I loads	Category II loads	Category III loads
	Generator	UPS / Batteries			
Main cranes				X	
Indoor transportation system - cranes					X
Indoor transportation system - trolley					X
Ventilation Annular space	X				
Ventilation Main Arch Volume					X
Ventilation Working area	X				
Ventilation Auxiliary buildings			X		
Ventilation Smoke exhaust - Working area + aux. Build	X				
Ventilation Smoke exhaust Main Arch Volume					X
Heating plant	X				
Cooling plant			X		
Circulation pumps	X				
Fire detection system		X			
Fire protection system				X	
Emergency exit system		X			
Power supply systems automatics and protection	X				
Lighting (2/3)					X
Emergency lighting (remaining lighting 1/3)			X		
Evacuation lighting		X			
Water supply					X
Fire water supply	X	X			X
Sewage system					X
Special sewage				X	
Storm sewage					X
Radiological monitoring		X			

Structures, systems and component	Category I Special group loads		Category I loads	Category II loads	Category III loads
	Generator	UPS / Batteries			
Structural monitoring					X
Seismic monitoring		X			
Communication		X			
Notification		X			
CCTV			X		
Integrated control system		X			
Local control system		X			
Central Monitoring panel		X			
Local monitoring panel		X			
Physical protection & access control			on client request		
CS-2 Equipment for dismantling					X
CS-2 Equipment for treatment					X
Dust suppression system			if needed, on client request		
Design provision	2 sources + a third independent self-sustained	2 sources + a third independent self-sustained	powered by 2 independent sources mutually backed up automatic inverter; less than 300msec. cut	powered by 2 independent sources mutually backed up automatic or manual inverter	powered by 1 source

A7.3 400V/230V electrical distribution

NOVARKA proposes the following principle for design of the electrical power supply system:

- Category 1 receivers are supplied directly by two electrical transformers;
- Electrical feeders of the category 1 provide power to the category 1 special electrical board, to the category 2 electro-receivers and to 1/3 of lighting;
- Electrical feeders of the category 1 provide power to the category 1 electrical board.

From the 6kV tie-ins points, in order to guarantee electrical supply of the 400/230V receivers, NOVARKA propose 4 transformers for distribution of NSC receivers:

- Two transformers for supply of the main cranes (including equipment);
- Two transformers for supply of the power trains (NSC equipment);

- And two transformers for the supply of the technical facilities.

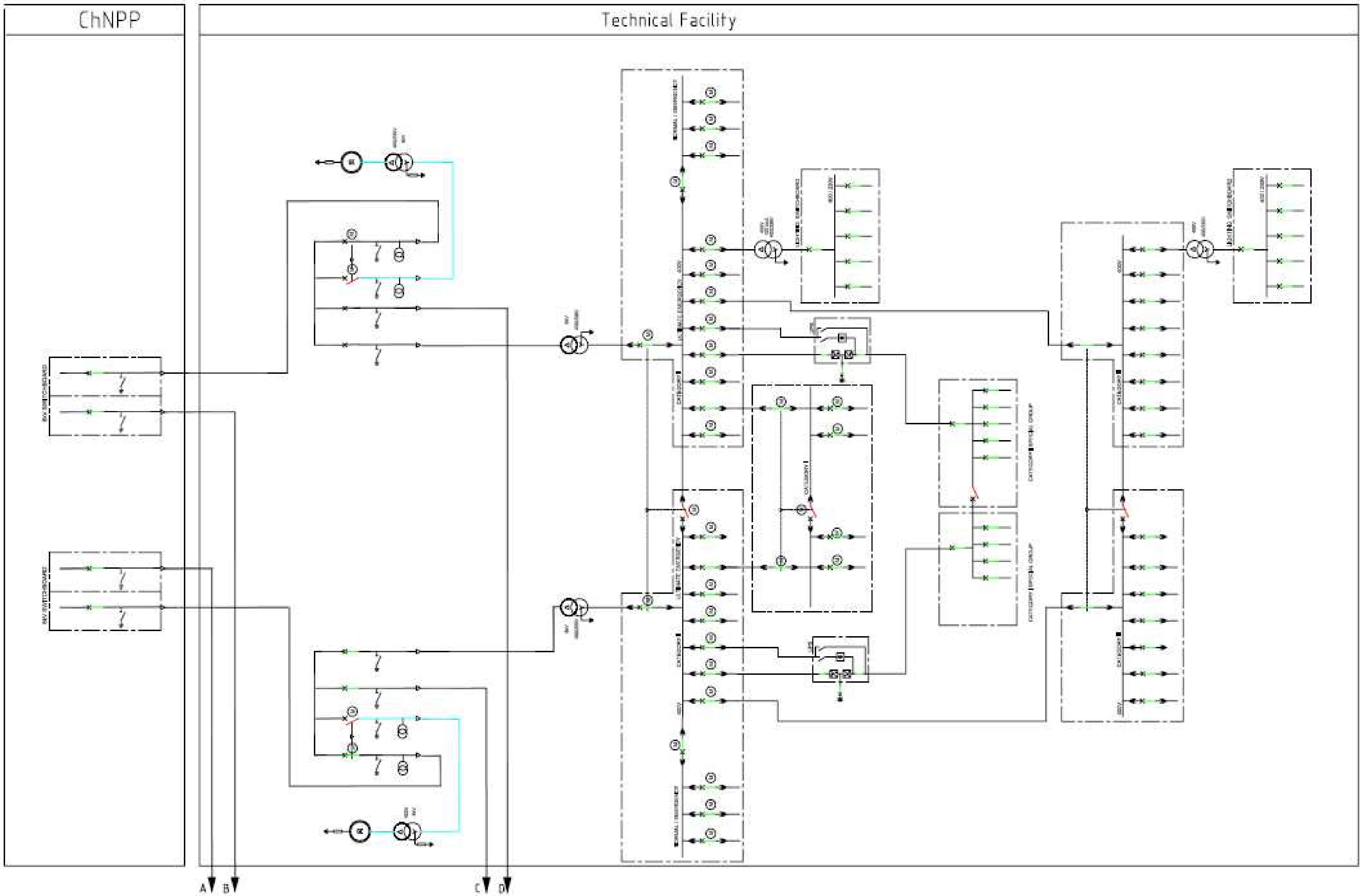


Figure A14. 230 - 400 V distribution diagram

A7.4 Grounding, lightning and aircraft navigation signs

A7.4.1 Grounding system

In order to avoid any unbalanced current circulation within the arch metallic structure, Novarka foresees a TNS neutral connexion, according to PUE Section 7.1.13.

A7.4.2 Earthing circuit

According to the PUE section 1.7.90, resistance of the earthing network shall not exceed 0.5 ohm.
In order to ensure efficient equipotential level, the arch perimeter must be surrounded by a continue conductive loop of 95mm² in braid copper. Inside this perimeter, each 12.5m, conductors are fixed to connect the arch metallic structure to the earthing network. The loop is buried at a depth in the range of 0.5 to 0.7m underground.

A7.4.3 Lightning protection

The NSC structure shall be protected against direct lightning strikes.

A safety grounding system will provide a low impedance path to protect against ground faults, static discharge and lightning.

A7.4.4 Aircraft navigation signs

With no additional information on the surrounding building, which could be higher than the future NSC, Novarka intend to install navigation signs.

A7.4.5 Lighting

Normal lighting will provide the following illumination levels, according to Snip II 4.79:

Table A15. Lighting levels

PREMISES	AVERAGE LEVEL (LUX)	REFERENCE POINT
Process areas (cutting, decontaminating	200	At ground level
Offices	300	0.8 m above ground
Warehouse	75	At ground level
Workshops	200	At ground level
Corridors	20	At ground level
Storage area	75	At ground level

Lighting will concern all the area of the arch where activities may occur. The upper zone of the Shelter Object must be lighted; the Dust Suppression System must be lighted to allow personnel to circulate properly.

Evacuation lighting will use stationary battery-backed continuously illuminated signs at exit doors and on evacuation routes.

Emergency lighting is intended for a safe shutdown of working processes in the event of a loss of power and shall provide a minimum of 5% illumination level. At this stage of the design, (Preliminary design), the emergency lighting functionality is assumed by dividing all lighting circuits between trains A and B, therefore providing the required lighting levels under a single fault scenario.

A7.4.6 Cables and cables ways

Inflammable conditions: Cables should be fire-retardant in order to reduce internal fire probability.

Radiation conditions: Minimum equipment will be installed in high exposition level area. Thus, most of the cable ways shall be in zone 2.

A7.4.7 Automation of the EPSS

Automation of the EPSS will ensure following functions:

- Defect management;
- Automated toggle switch management;
- Load splitting and reconnecting management;
- MCC control automation;
- Emergency stop.

A8 INTEGRATED CONTROL SYSTEM

A8.1 Description of the system

The Integrated Control System (ICS) will consist of monitoring and controlling NSC systems.

Monitoring is the recording and observation of activities. It allows the operators to carry out surveillance of the New Safe Confinement (NSC).

Control will enable the operator to remotely control a device (start/stop, positioning, diagnostic, etc…), analyse a situation and maintain the equipment of the NSC.

Proposed architecture, available in chapter 5.2, presents equipment of the ICS system and their connection.

A8.1.1 Systems related to the ICS

The ICS communicates with the following sub-systems.

- Monitoring systems:
  - Radiation monitoring (RMS);
  - Seismic monitoring (SMS);
  - Structural and foundations monitoring (SSMS);

- Operation support systems:
  - Heating, ventilation and air conditioning system of the annular space;
  - Heating, ventilation and air conditioning system of the NSC main volume;
  - Water supply and sewage system;
  - Power supply system;
  - Main cranes;
  - Indoor transportation system;

The ICS will interface with existing or new independent systems, such as:

- FPS – fire protection system;
- SIP task 17 Object Shelter (OS) integrated Automated Monitoring System (IAMS);
- SIP task 18 Integrated Shelter data base (ISDB);
- Physical protection and access control system (PPS).

Note that all independent or external system will be connected to the ICS via the Ole for Process Control (OPC) standard, except the PPS, which will be hard-wired for security reasons.

A8.1.2 Architecture description

A8.1.2.1 Servers

- **Redundant normal/backup application servers** process information acquisition from the NSC operation PLCs and external systems. The application server classify alarm signals and activate the stand by duty calls. In case of a default of the active server, backup server will carry out all of its function.

- **Historic Data storage** consists of PCs with redundant hard disks, ensuring data storage (warnings, events, remote control, measures, reports, order arrays).

A8.1.2.2 Acquisition and supervision of redundant network

Industrial communication network, with redundant ring typology, based on the Ethernet TCP/IP protocol, high speed network with optical fibre, shall ensure connections between all of the equipment of the ICS and the local field PLC.

This network allows communication between PLCs, for information which are not transiting through the safety PLC.

Industrial switches for communication with the field PLC are inside the PLC cabinets.

Two different ways will be planned for the network routes.

Administration and network analysis station allow for monitoring and registering of all network equipment.

A8.1.2.3 Operations and programming workstations within the central control room

- **System administration and programming workstation,** for upgrade and modification of the system. This station will benefit from tools for analysis of historical data and will allow manual or automated creation of report in the Excel format. It will be equipped with a time stamping card for synchronisation of the timers of all equipment of the ICS, including operation station.

- **MIMIC** for statements synthesis for each area coming from the redundant acquisition server's real time database. It displays status like:

  - Access : Authorised/Controlled/Forbidden;
  - Personal attendance;
  - Work modes of the NSC (standby, maintenance, tests, run…);
  - Clock for the site time;
  - Emergency stop buttons.

- **ALARM ANNUNCIATOR** displays summary of all failing soft modes coming from the safety interlocks controller or from the field, by direct wire connection.

- **Administration and network analysis station** displays status of each piece of equipment (traffic, collisions, load rate, address map…).

- **Facility Operation Supervisor workstation**, remotely located in the NSC administrator office

- **Two double screen facility operator's workstations** dedicated to the operation personnel, which take into account warning, implement backup operation and warn the chief administrator, depending on the criticality and consequences for workers and the NSC

- **One double screen station for the chief facility operator**, for supervision of the different operations, management of operating modes (modification of order array for operating modes), and update of alarm register.

- **One PLC programming console**. Modification of programming will be implemented from the ICS, online, with agreement from the chief facility operator.

<u>Notes</u>:

- For safety reasons, in addition to comfort and maintenance issues, all PC will be mounted within cabinets, in an air-conditioned room, isolated from dust. Keyboards, screens and mice will be outsourced in the central control room.

- Every station will be commercially available.

- Electric network of the central control room will be securely powered with 90 minutes autonomy UPS. PLC and network equipment will similarly be supplied.

A8.1.2.4 Local operation supervision station

Each **local control panel** is dedicated to one operation system or sub system of the ICS.

A8.1.2.5 One Safety Interlocks PLC

The following functions are safeguarded by this safety interlocks PLC:

- Take into account critical information coming from the field with direct physical connection and via the Ethernet network (emergency stop button, alarm summary for each operation system);

- Calculate inconsistency between direct physical connection and the network connection;

- Broadcast critical information to the different operative systems;

- Manage automatically the work modes of the NSC, as well as the work modes modified by the chief facility operator;

- Send critical status to the alarm annunciator;

- Depending on scale and complexity of operation systems, it can be the master PLC for calculations of the fail soft modes of operation systems.

Notes:

- To comply with safety constraints, this PLC shall benefit from three redundant CPUs. However, interface with operational elements (sensors, motors) will not be redundant.
- Loss of a normal rack dedicated to operation system is detected by the safety interlocks PLC, which will light up a "Failure" signal on the operation cabinet. This information will also be transferred to the chief operator workstations trough the real time server.
- Digital signal shall respect 4 logic states: Open/ Closed / Short circuit/ Line Break

A8.1.2.6 Characteristics of collect equipment (OUT of the ICS scope of work)

Control command cabinet

One or several cabinets dedicated to control command will be installed next to every operation system. It will be equipped by uninterrupted power supply with 90 minutes autonomy.

They shall contain at least the following elements:

- Main racks of the redundant PLC with 3 redundant CPUs;
- Unique Input/output rack (non-redundant);
- Operator panel, allowing local monitoring and control of the process or parameter settings;
- Local/ remote display device which control local overrun (for instance to switch a pumping device on);
- Relay voltage status ;
- Open door detector;
- Mirror terminal blocks.

Operators will be able to switch to the distance mode on the local PLC (Run/stop modes will be studied in detail).

Master PLC

In cases with an operation system needing several PLCs, one Master PLC should take place and control the system. It may reallocate tasks in case of a failure of one PLC to the other system's PLCs. This PLC will benefit of 3 redundant CPU if it is identified as important for safety (IS-1).

Operational parts (sensors / actuators)

Information from the emergency stop button or from the alarm summary are transferred by multiple dry contacts to the operation systems, the safety interlock PLC, and the summary display panel in the central control room.

Sensors and actuators are not systematically redundant.

Instrumentation stations and the acquisition gateways will be on slave modbus RS485 protocol, up to the redundant PLC.

Existing system

Existing systems are the following:

- **Existing supervision system (SO IAMS) and the data base (ISDB)**: Particular information will be transferred to the ICS.

- **Physical protection and access control System**:
  - Personal attendance per zone will be transmitted to the ICS via an OPC server;
  - Unavailability of the access control: power supply defect, battery defect, sanitary lock defect, general defect will also be taken into account by the ICS.

- **Fire protection system**: the ICS takes into account at least the following:
  - Fire alarm summary;
  - Unavailability summary;
  - Particular ventilation operation cabinets shall receive orders from the smoke exhaust scenarios calculated by the fire fighting central command.

A8.1.2.7 Redundancy

In order to ensure a single fault tolerance system, main components (CPU, PLC and network) are redundant. A single default or a maintenance operation will have no impact on the system operation.

Switching in case of a default must be automated.

System shall be configured, maintained and extended, without disturbing the system.
Help functions must be available and easy to access at any time.

PLC-CPU redundancy:

Concerning the safety important PLC, a TMR (triple modular redundant) type architecture will be implemented. This type of architecture is both safe and widely available; it works in 2oo3 mode (3-2-0). The system process vote or make comparison diagnostic. The system is constituted of 3 independent channels which are connected so that only 2 of the 3 channels need to be operational to have the safety function working. It is not allowed to work in a single channel mode.

The operating 3-2-0 mode is as follow:

- Operating with 3 CPU;
- Then with 2 CPU;
- Then emergency stop after default of one of the two remaining CPU.

Server redundancy:

In order to ensure a maximum availability level to the system, a server redundancy will be implemented; In case of a default, the switch to the backup server will be automated.

Network redundancy:

For the architecture to ensure high availability, the communication network with a ring topology will be redundant. In addition, two separate transmission ways are foreseen for network pathways.

Power supply redundancy:

Uninterrupted power supply will be redundant.

A8.1.2.8 Supervision Software

The software to be used will be a well recognized industrial standard.

It will be possible to collect background plans in an AutoCAD format, in order to settle background for the Graphical User Interface for geo localization of all the points.

Operating system used for stations and servers will be Microsoft Windows.

A8.1.2.9 PLC Software

The PLC software shall respect 4 normalized languages:

- Function blocks;
- Structured text;
- Ladder logic;
- Sequential function charts.

A8.1.2.10 System self-diagnostic

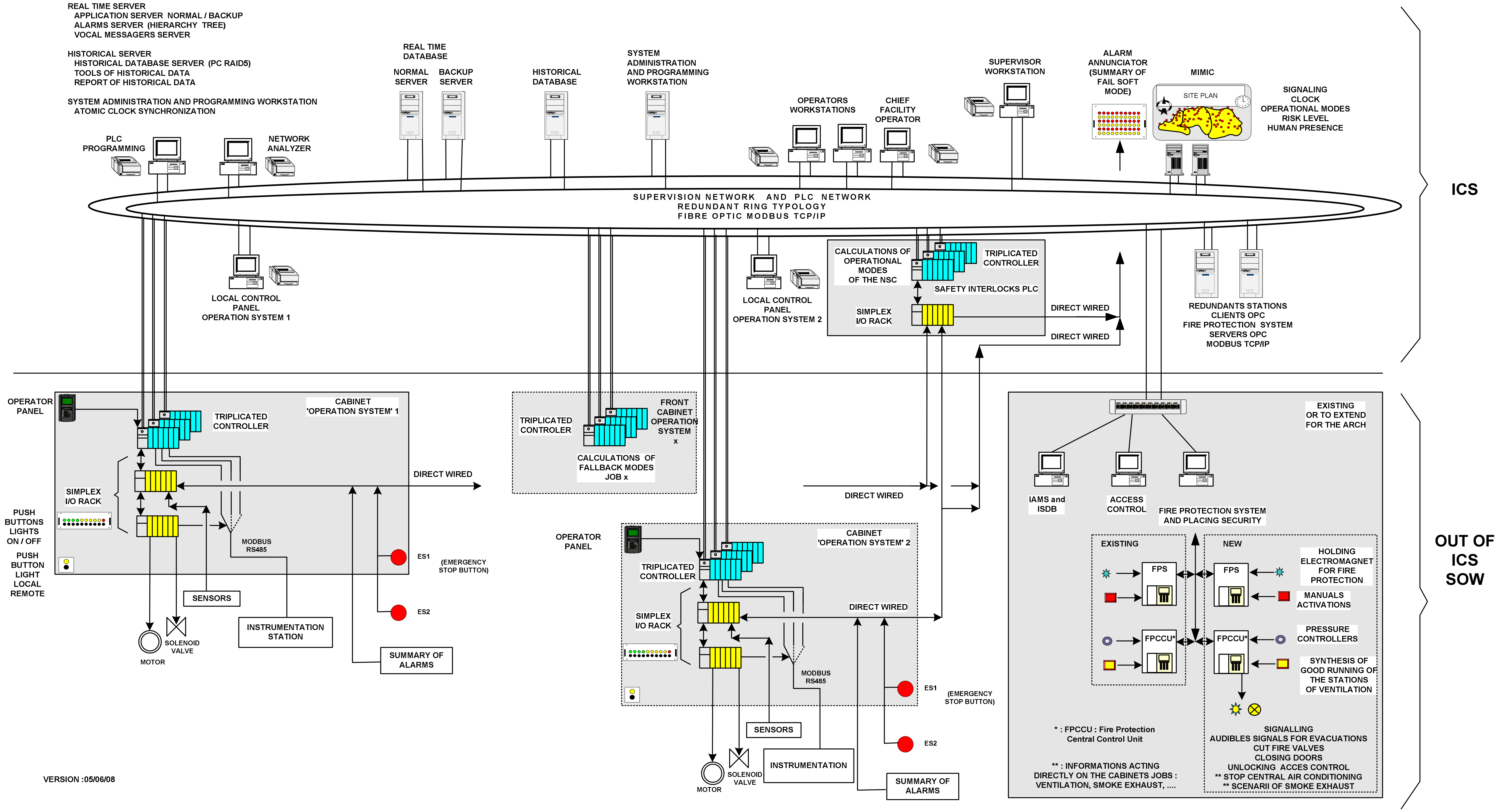
Every possible dysfunction of the ICS will be detected in real time and transmitted to the safety agent, which will contact the relevant personnel, depending on the consequences of the accident.
Every dysfunction of the ICS will be registered as alarm events.

They can be:

- Station default;
- Power supply default;
- CPU default;
- PLC card withdrawal;
- PLC card default;
- Network breakdown…

A8.2 General System Architecture

SYSTEM ARCHITECTURE OF THE NEW SAFE CONFINEMENT ICS



A9 INDOOR TRANSPORTATION SYSTEM – CONFINEMENT AND AUXILIARY FACILITIES – INTERNAL ARRANGEMENT

A9.1 Ground level

The local area (platform) in front of the western wall of the OS is currently at a level of +120m, almost flat levelled on an average square delimited by the turbine hall, the DSS buttress and the present OS access.

Digging – excavating in the Local Zone being unconceivable for radiological reasons, we have chosen to build the NSC building on a large concrete platform.
Its total thickness of it should be around 1,2 – 1,5 m thickness in total, increasing the final working ground level to roughly +121,5m.

The DSS buttress area being at level +123m, the remaining difference with our working level is reduced by a factor of 2, permitting the construction of a road around the buttress. This horizontal circulation link allows a free and total access under the entire arch between the Laydown area and the Buffer storage area, enabling to deserve all areas and facilities.

A9.2 General layout

(See Figure A15)

The spatial organization is illustrated on the figure below, regarding the Arch position and the Main Cranes hook catching area, indicating also the main surface areas and subsequent volumes when needed.

The building is erected partially under the arch and partially outside, with the intent to locate most of the controlled zone 2 volumes inside the arch for safety reasons, and the "cold" auxiliaries outside.
It does not impact to the actual OS access and a 5m large corridor remains with free access to it until the full erection of the NSC.

Location of the concrete Eastern wall allows:

- To expand the Lay down Area (see below);
- To create a communication road under the DSS buttress (see above);
- To create a radiological shielding for all activities settled west to it, including most of the erection works.

Location of the parallel western wall is due to the position of the western double-skin wall of the arch, which also needs to be linked to the reinforced structures.

Access is strictly limited to the followings:

- Northern Gate: airlock main access for trucks;
- Southern Gate: airlock access for oversized vehicles ;
- Main entrance: *unique* personnel access inside NSC building;
- Large *emergency* airlock to allow access to the south gallery for firemen trucks;
- Personnel emergency airlock on the east side of the south gallery.

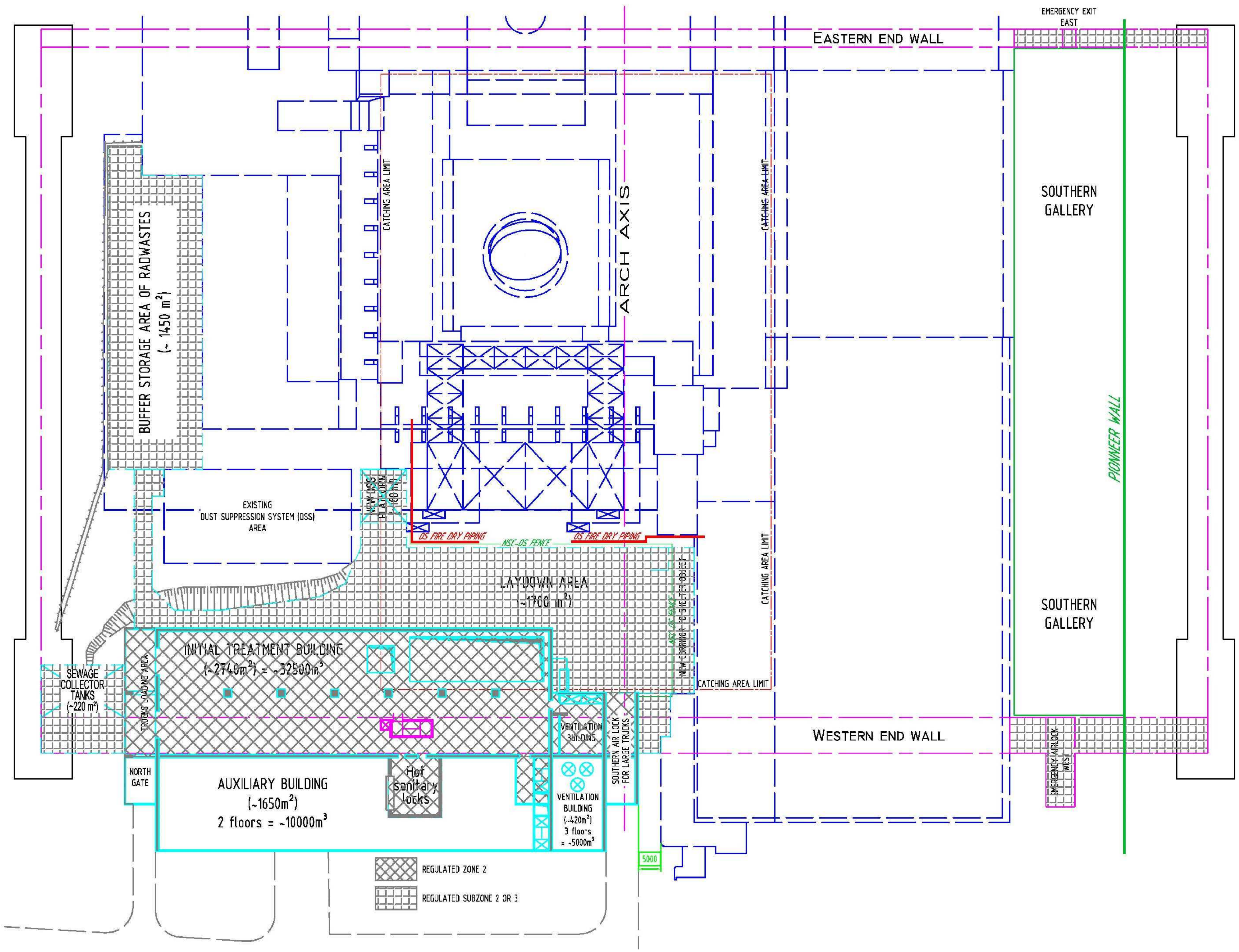


Figure A15. General layout

A9.3 Initial treatment building

(See Figure A16)

This controlled zone (zone 2) building is mainly composed of:

- A wide double vault sized 96m x 28m x 10-12m height, running North to South on the western side of the NSC and physically settled under the arch and its western double-skin wall:

    1. Each vault of this twin volume is covered by a 20T bridge crane and a 15T trolley.

    2. The Northern Airlock is composed of the truck airlock itself at level +120,20m, with a second airlock platform at its rear allowing the loading of a truck trailer with the 20T Forklift coming from the arch area (Lay down or buffer storage areas at level 121,5m). The 20T bridge cranes also service these two northern airlocks, this location also being their maintenance garage.

    3. The two electrical 15T trolleys can be driven either on each parallel tracks inside the vault. The eastern track also services the second airlock platform in order to create a junction loading point between the 20T crane, 15T trolley & 20T Forklift. This second airlock can also be used as a garage for the Forklift.

    4. These vaults are wide enough for the location of :
        - An Initial Treatment Area under the roof opening (30 x 10m access deserved by the main cranes of the arch), with all necessary tie-ins (see below);
        - 8 working areas defined as 12x12m squares, individually equipped with all necessary tie-ins (Industrial water, special sewage water collection, compressed air, breathable air, electrical supplies, audio & video, ventilation duct on stand-by) and ready to receive any kind of workshops for CS2 and CS3 activities;
        - Shops, workshops and storerooms, exit control points on both truck airlocks, corridors, access to the controlled zones of the ventilation building;
        - Worker airlocks between Zone 2 & Zone 1 with IPM sanitary locks, equipped with all the above mentioned necessary tie-ins.

    5. A "Hot" sanitary locks sized for 120 persons (10% women), is sited as the *unique* access way to the inside of the NSC, as a strict border between Zones 3 & 2.

    6. A corridor and stairs (eventually a service lift) for reaching the reinforced roof inside the double skin of the western wall, for access to the lift walkway to the telescopic mast garage under the arch and to the stairs;

    7. As above, the roof inside the double skin is used as a pathway for workers for reaching all mechanisms settled on the roof inside the arch, such as the lifters of the airlocks doors, the technical galleries housing the duct networks, the stairs to the Laydown area, etc…

- A Ventilation building with 3 floors, of same height as the ITS vault, with all radiological monitored rooms located under the arch or the double-skin west wall.

- A large Southern Airlock for access of large vehicles or cranes;

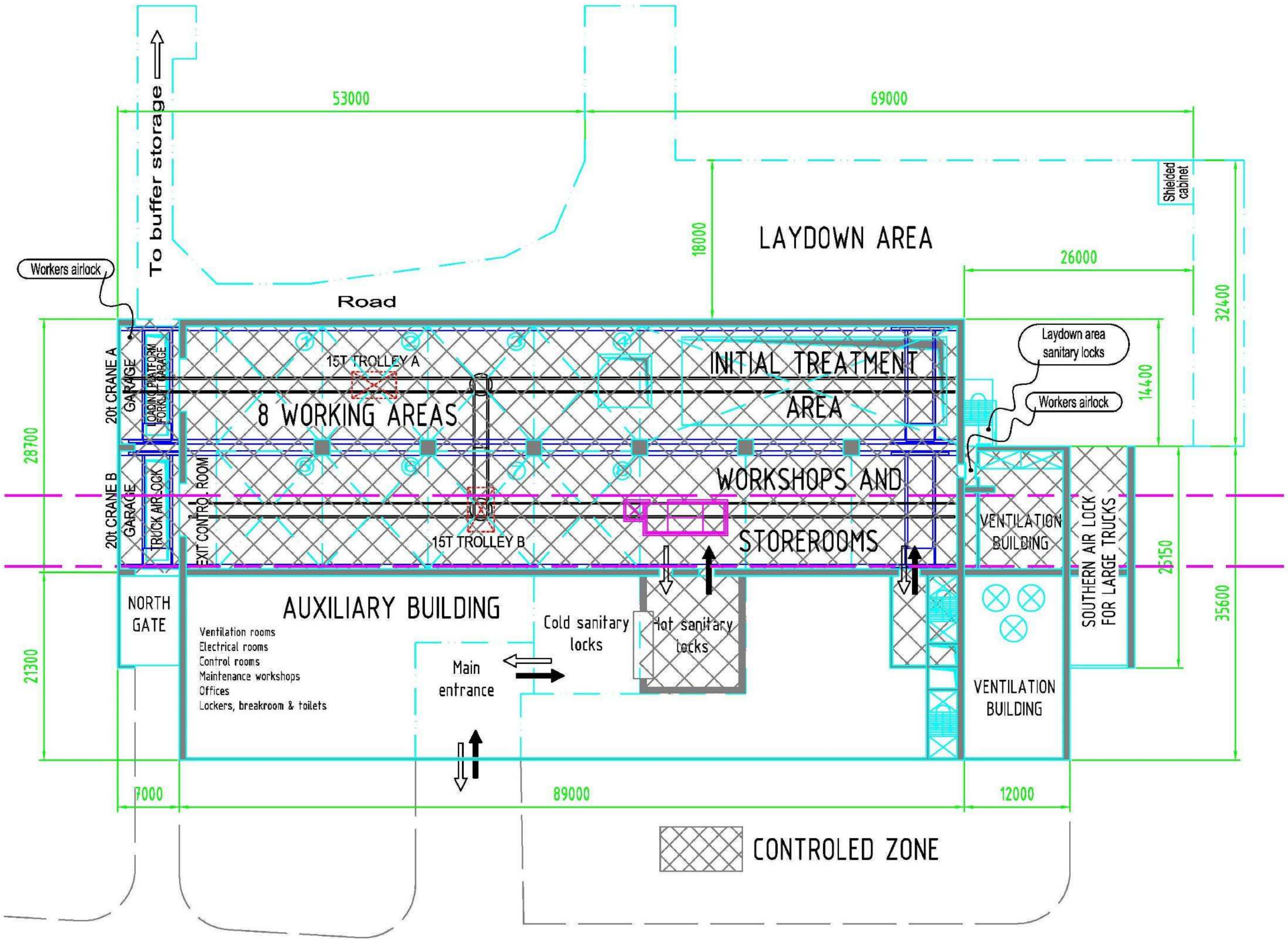


Figure A16. Layout of the initial treatment building

A9.4 Auxiliary building

This "civil" zone (zone 3) houses all the facilities needed for managing the NSC, and is physically located on 2 floors outside the arch. It includes:

1. The main Hall Entrance for the personnel, where the access control shall be settled, with adjacent vehicle access door for "Cold" supplies delivery;
2. The "Cold" sanitary locks, sized for 120 persons including 10% women, the *unique* entry way to reach the "Hot" sanitary section and the controlled zone 2;
3. Main Control Room and offices;
4. Maintenance workshop;
5. Storerooms, corridors, break room, toilets, stairs etc…;
6. Electrical rooms & control board;
7. Radiation monitoring shop, Medical room, etc…...

A9.5 Laydown area

(See Figure A17)

The laydown area is approximately 1700m², spatially limited:

- On the East side by the OS Fire Dry Sprinkler System Piping (A.68 p.50) running parallel to the FM-1 & 2 foundations at an estimated distance of 4 meters,
- On the west side by the Initial Treatment building or by the west wall of the arch,
- On the south side by the "new corridor to OS",
- On the north side again by the IT building or by the DSS buttress.

The Laydown Area has been enlarged in order to provide at the most, around any of the largest beams issued from CS-2 unstable structures dismantling, a working corridor 3m wide, plus a perimeter 1 meter large for the erection of a scaffolding - confinement, plus a 3m wide surrounding corridor for circulation around it.

The optimal arrangement is shown in figure 19 below, taking into account the maximal lengths and widths of the largest deconstructed structures, surrounded by a 7m spacing:

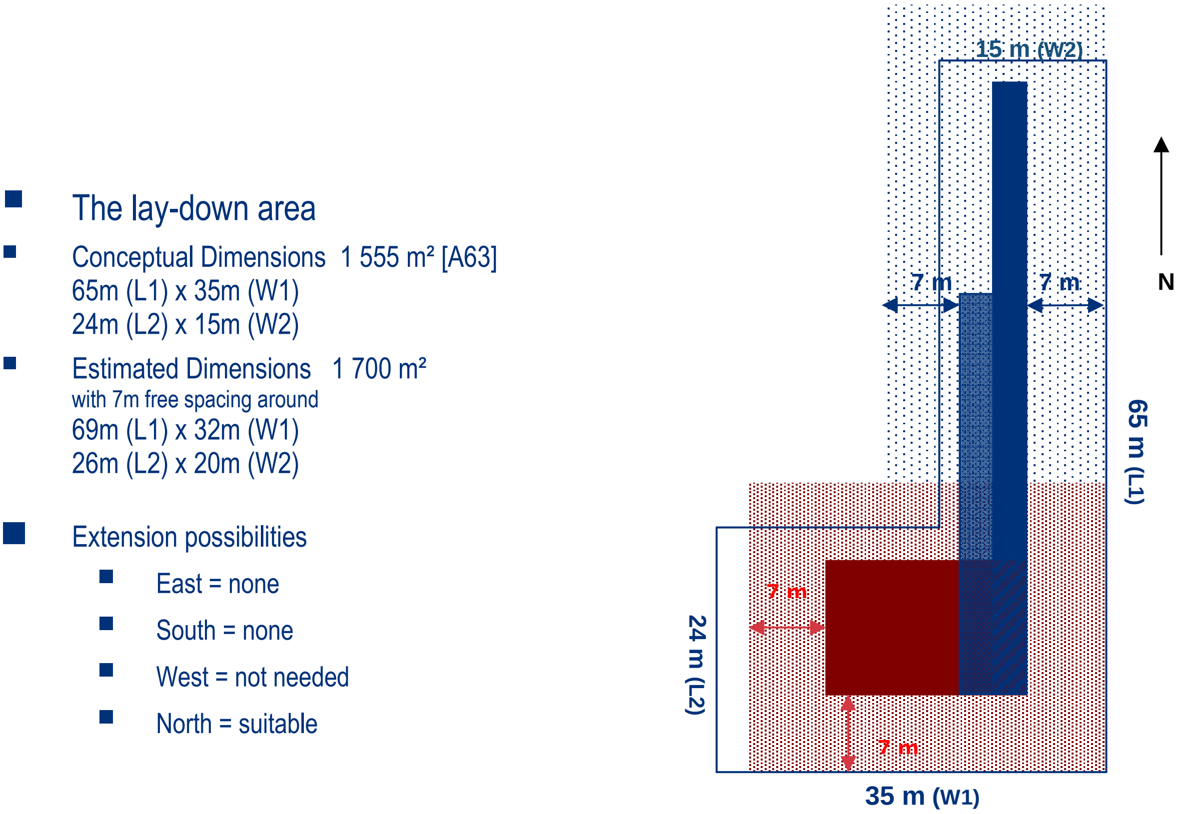


Figure A17. Dimensions of the laydown area

Actual position of the arch over the OS, after dismantling the ventilation Stack, allows us only 18m for (W2), which we can afford because it is used only for the dismantling of the 1,6m large B1 beams including our 7m surrounding prospect area.

A9.6 New DSS platform

(See Figure A15)

The location of the New DSS must be established within the catching area of the main cranes. A platform of average 160m² will be created next to the actual DSS buttress, in the corner with the northern FM-1 foundation block. All necessary tie-ins coming from the existing DSS will be installed ready on the platform in order to serve directly the New DSS.

A9.7 Buffer storage area

(See Figure A15)

The Buffer Storage Area is settled on the remaining flat surface north of the cascade wall at level +123 / +124m, limited towards the north of the arch by a useless 7m gap down to level +116m.
The average surface should be of around 1500m², enough to store up to 160 KNPU containers, possibly expandable to the west toward the Northern Truck Airlock and the Sewage Collection Area.

A9.8 Sewage collection

(See Figure A15)

Apart from the Initial Treatment Building itself with its built-in sewage collection network, all working areas under the arch (illustrated with a square font on the main layout figure) are covered with a waterproof floor including slopes & gutters to recover the waters in the local + main sink holes.

LRAW is then pumped from these sink holes, through SS ducts, up to storage tanks located on a Sewage Collection Tanks Area between the arch boundary and the truck airlock, ideally located for an easy drain off into tanker trucks.

A10 MAINTENANCE GARAGE FOR MAIN CRANES

The purpose of this chapter is to summarize all the elements we have taken into account for the preliminary design of the garage. Explanatory sketches are included at the end of the section.

A10.1 Reference documents

1-Attachment 37.1
2-Attachment 37.2
3-Attachment 37.3
4-Attachment 37.4
5-Attachment 68
6-Attachment 63
7-Attachment 16

A10.2 Functions of the garage

The garage is integrated into the arch main structure. It is located between two main arches directly at the level of the trolley rails, in a location that leaves enough room for the storage of the two Western quadrilaterals along the Arch West wall.

A10.2.1 Protection of personnel during maintenance activities

- Shielding;
- Ventilation;
- Radiological safety;
- Escape routes.

A10.2.2 Performance of activities linked to the maintenance of the crane and the dismantling programme

On the basis of NOVARKA's understanding of the dismantling programme, we have listed below the activities that can be performed in the garage:

- Maintenance and storage of trolley on the top platform: this includes the maintenance to be done on mast carrier trolley. The situation of the trolleys could be as follows:
  - One trolley in decontamination and maintenance;
  - One trolley stored close to the garage, between the garage door and the quadrilateral.
- Maintenance and decontamination of the mast tools and devices that are carried by the mast on **the middle platform and lower platform**:
  - Hydraulic power station;
  - Dust vacuum cleaner maintenance;
  - Remote controlled arm;
  - Dismantling tools.
- Waste management:
  - Removal of EPA & HEPA filters;
  - Removal of dust container.
- Tools storage and light maintenance on the **bottom platform** (dismantling tools)

In addition the garage should also ensure the following special actions:

- Lifting of the mast from the ground level to the garage level using an existing trolley;
- Access to the quadrilateral through the walkway;
- Lifting of accessories and spares from the ground level to the garage level;
- Access to the mast platform when fully deployed i.e. failure.

Please note that the thickness of the shielding of all the faces that are directly exposed to the radiation will not exceed 3 cm (roughly 300 kg per square metre). As written in the referenced attachments, no shielding will be installed on the walkway. The access to the quadrilateral will be done through the use of a safe mobile shielded protection.

A10.3 General arrangement

In order to ensure the main functions that are listed above, the garage will be equipped as follows (First approach).

A10.3.1 Safety and health physics, protection of people

One of the main options taken into account is to close and ventilate the access corridor, the change room and the garage. This will make the work easier for:

- The work to be implemented in the garage;
- The work of the health physics people and the access without wearing respiratory protection for the daily routine activities:
    - Zoning control and classification;
    - Filter change on air sampler;
    - Monitoring of clothes;
    - Secondary waste segregation;
    - Removal of contaminated secondary waste;
    - Removal and replacement of contaminated clothes and equipment.

  And other depending of the on site activities

The garage will be equipped with all safety provisions:

- Confined ventilated (ventilation & smoke exhaust if necessary) and shielded access;
- Confined ventilated (ventilation & smoke exhaust if necessary) and shielded emergency exit;
- Change room ventilated and shielded and equipped with:
    - Clothes, mast, respirator etc…
    - Portable contamination monitor.
- Radiation monitoring and alarm on each platform and change room;
- Airborne monitoring and alarm on each platform and change room;
- Access to the walkway or to the shielded vehicle;
- Confinement and ventilation of the garage itself during standard safe operations when the doors are closed;
- Fire alarm and fire detection;
- Hygienic air alarm;
- Survey camera on platform (linked to control room);
- Phone line on each platform;
- Direct headphone line linked to the control room;
- Portable emergency respiratory air supply on each platform;
- Lighting;
- Emergency lighting;

- Fire protection devices;
- Tannoy.

A10.3.2 Power supply, tools, spares, auxiliary

For all platforms:

- o Electrical supply 400V and 220/230V;
- o Compressed air;
- o Hygienic air;
- o Hot water if required for decontamination purpose;
- o Service drain or tank for temporary storage of contaminated water before transfer to the ground if decontamination is made using water or liquids.

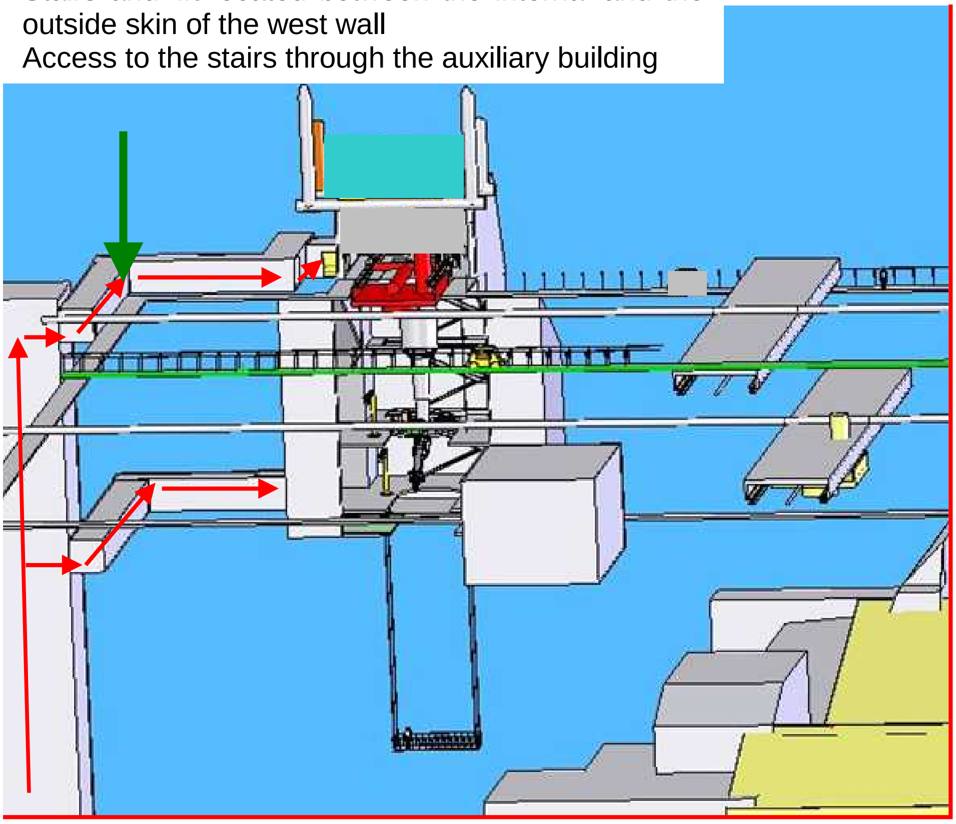
A10.3.3 Special tools or devices to be added on the platforms listed below:

- Top platform:
  - o Overhead crane for general lifting inside the garage.
- Middle and lower platform:
  - o Gantry crane for tools or waste services.
- Bottom platform:
  - o Sliding door that can be opened to give enough room to enter in the garage the standard mast when fully deployed.
- Bottom platform:
  - o An auxiliary mobile platform linked to the bottom platform through a 4 winch system that gives the possibility to have access to the mast platform for example in case of failure when the mast is deployed.

A10.4 General overview

A10.4.1 General arrangements

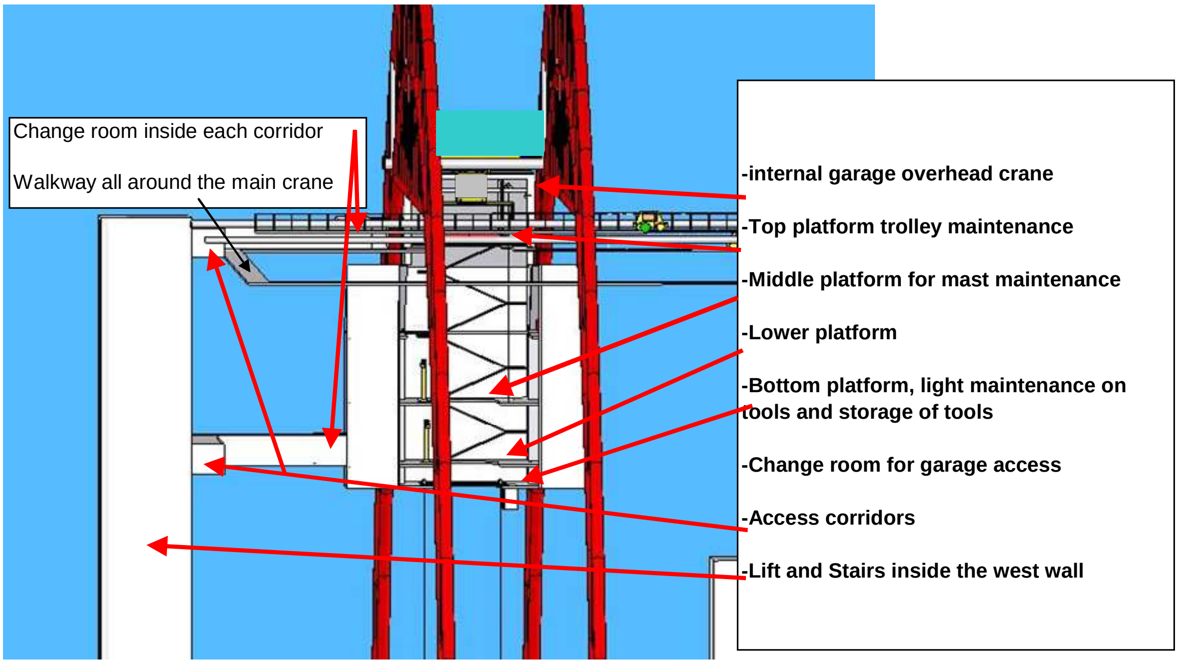
Stairs and lift located between the internal and the outside skin of the west wall
Access to the stairs through the auxiliary building



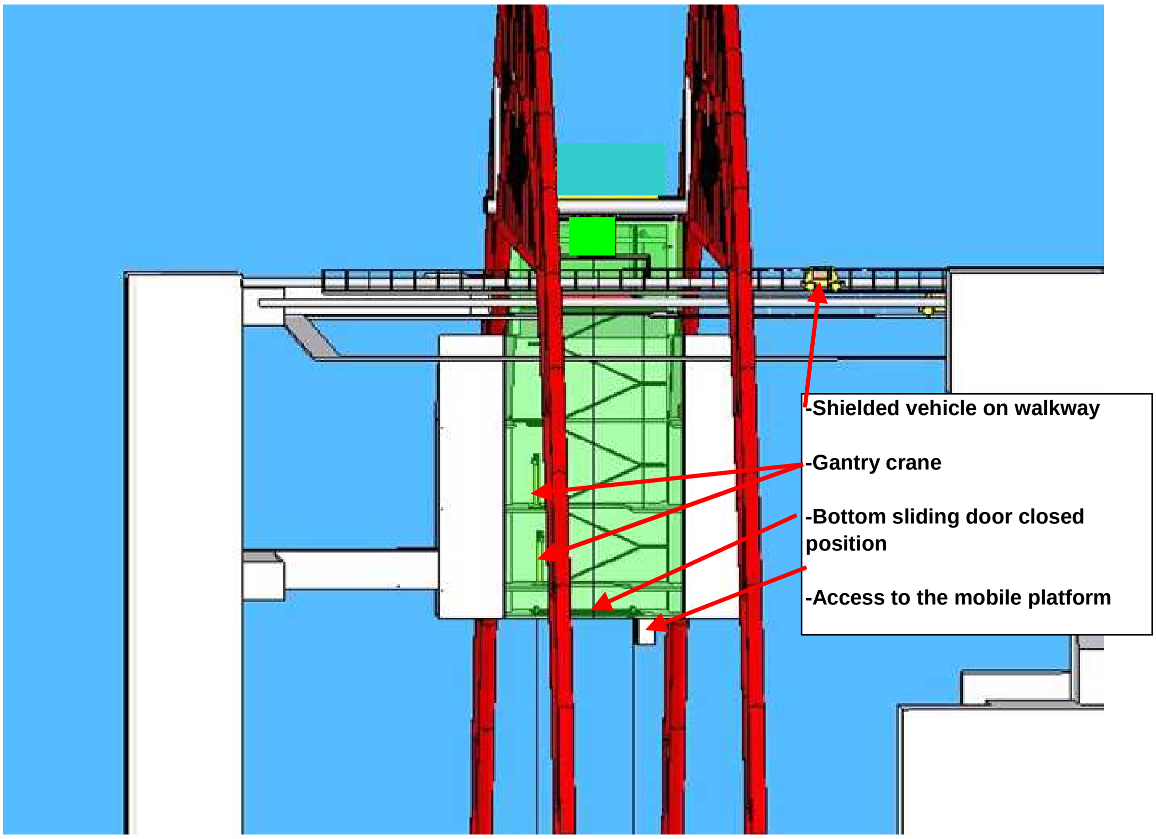
In this view we see

- Escape and access route in red
- Walkway
- Quadrilateral
- One change room with footpath
- Shielded safe vehicle (Att A37.2)

A10.4.2 General overview with opened doors:



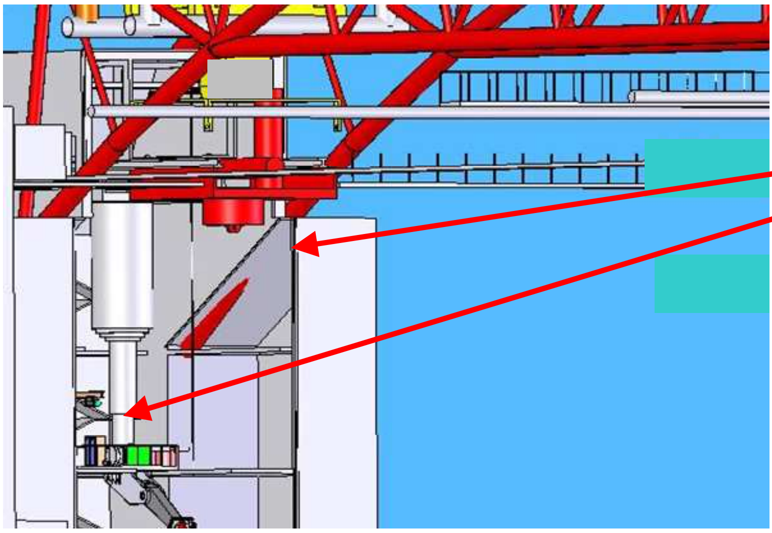
A10.4.3 General overview door closed



A10.5 Garage configurations

The doors that are closed during operations remain open on the pictures to give the best view of the situation inside the garage

A10.5.1 Maintenance and storage



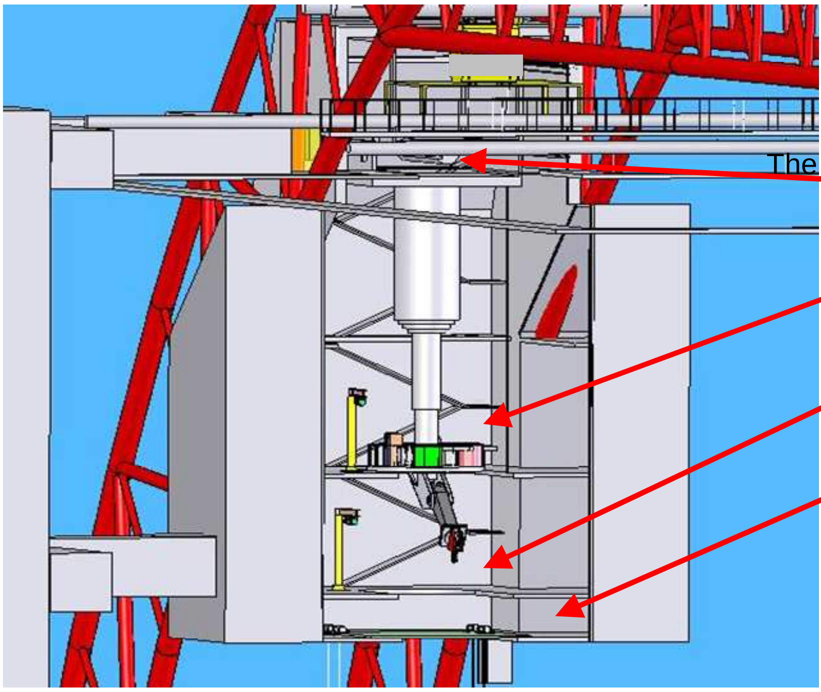
In this configuration:

- One trolley in storage position
- The mast is in maintenance position

We can also see:

- The 100 ton hook

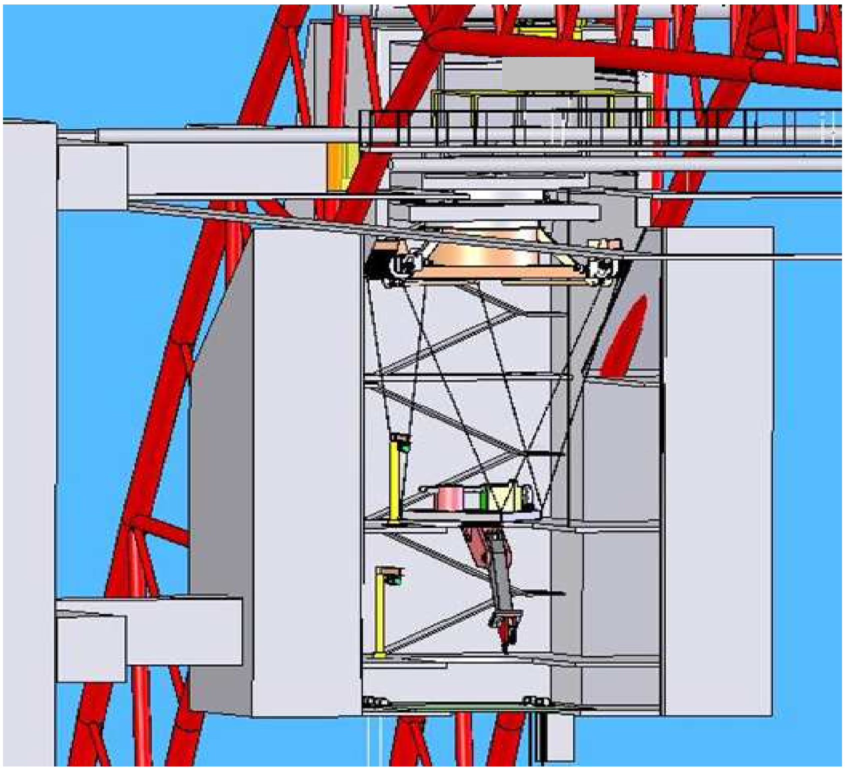
A10.5.2 Standard mast in maintenance position



The mast is in the garage

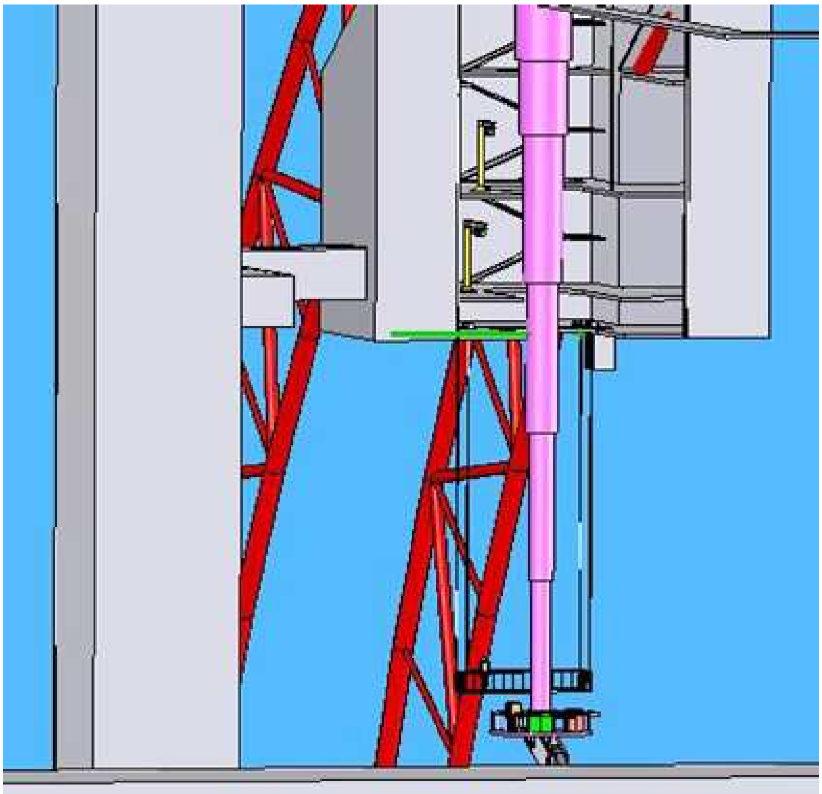
- Maintenance of trolley and mast winches
- Maintenance of filters and other
- Arm and dismantling tool removal
- Light tool maintenance and storage

A10.5.3 Cable mast in maintenance position



At this time the choice between the telescopic mast and tensile truss is not made but the maintenance and other activities will remain the same for either solution

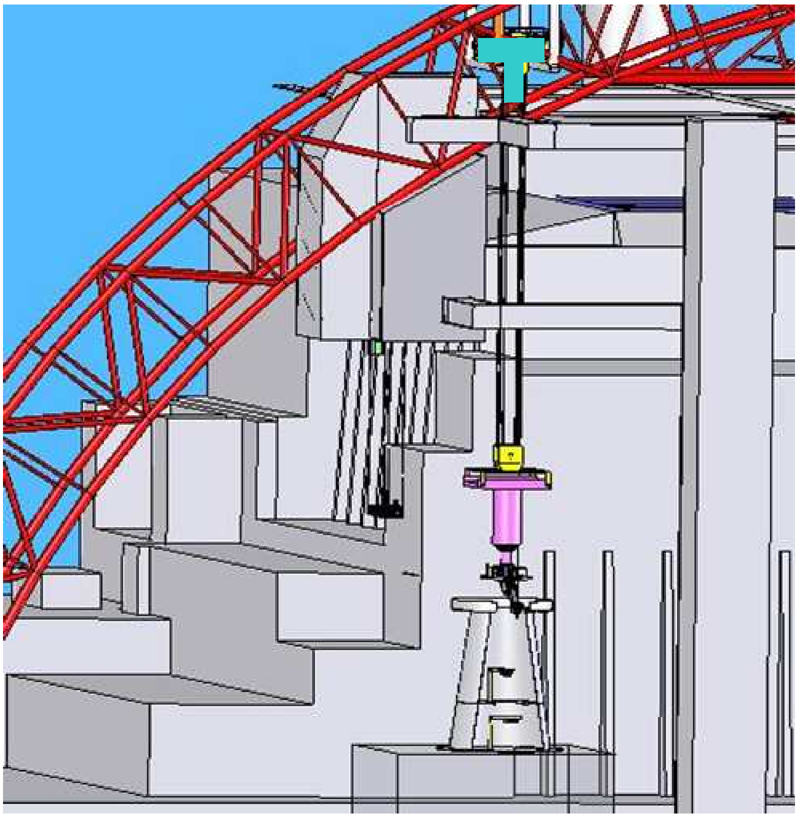
A10.5.4 Mast fully deployed in the garage



At this stage the mast is fully deployed in the garage for the following reasons:

- Decontamination purposes: in this case the bottom sliding door is opened, workers operate wearing respiratory protection devices
- In case of failure, as shown on the picture, we can access the mast using the mobile platform

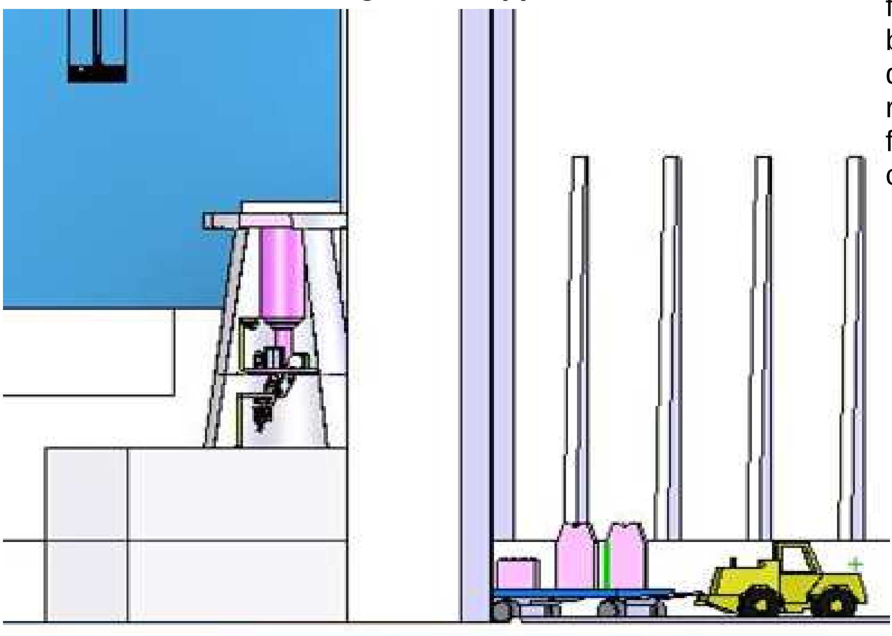
A10.5.5 Mast moving down to the ground



The mast is lowered down in the following cases:

- Major failure
- Arm removal
- Installation of heavy tool
- Replacement of the mast itself

A10.5.6 Mast on it's ground support frame



The mast is on its ground support frame located up to the auxiliary building. Transferring the mast directly in the waste treatment room will be a good solution for filter change and dust vacuum cleaner waste removal

The purpose of this chapter is to summarize the entire elements we have taken in account for the preliminary design of the garage. It includes explanatory sketches at the end.