Chernobyl New Safe Confinement

The **New Safe Confinement**(**NSC** or **New Shelter**) is a structure built to contain the remains of the No. 4 reactor unit at the Chernobyl Nuclear Power Plant near Pripyat, Ukraine, destroyed during the Chernobyl disaster in 1986. The structure also encloses the temporary "sarcophagus" built around the reactor immediately after the disaster. It will prevent the release of contaminants from the existing shelter and protect it from any external influence.[1]

As part of the Shelter Implementation Plan supported by the Chernobyl Shelter Fund, the NSC was designed with the primary goal of constructing a sarcophagus capable of containing the radioactive remains of Reactor 4 for the next 100 years. It also aims to allow for a future partial demolition of the original sarcophagus, which was hastily constructed by Chernobyl liquidators after a "beyond design-basis accident" destroyed the reactor on April 26, 1986.

The word *confinement* is used rather than the traditional *containment* to emphasize the difference between the "containment" of radioactive gases--the primary focus of most reactor containment buildings, and the "confinement" of solid radioactive waste that is the primary purpose of the New Safe Confinement.

The NSC is designed and built by the French consortium Novarka with 50/50 partners Vinci Construction Grands Projets and Bouygues Travaux Publics.[2] Having been moved into place, it is scheduled to be entirely completed in 2018.[3][1]

In 2015, the European Bank for Reconstruction and Development (EBRD) stated that the international community is aiming to close a €100 million funding gap, with administration by the EBRD in its role as manager of the Chernobyl decommissioning funds. The total cost of the Shelter Implementation Plan, of which the New Safe Confinement is the most prominent element, is estimated to be around €2.15 billion (US$2.3 billion). The New Safe Confinement alone accounts for €1.5 billion.[4]

Chernobyl New Safe Confinement

Новий чорнобильський саркофаг

The New Safe Confinement at Chernobyl Nuclear Power Plant in its final position over the damaged Reactor 4 in October 2017

General information	
Status	Under construction
Type	Containment structure
Architectural style	Arch-shaped steel structure
Town or city	Pripyat
Country	Ukraine
Construction started	September 2010
Estimated completion	2018
Cost	€1.5 billion
Client	Government of Ukraine
Height	92.5 metres (303.5 ft)
Dimensions	
Other dimensions	external span 270 metres (885.8 ft), length 150 metres (492.1 ft)

Contents

Design and construction	
Main contractor	Novarka with 50/50 partners Vinci Construction Grands Projets and Bouygues Travaux Publics

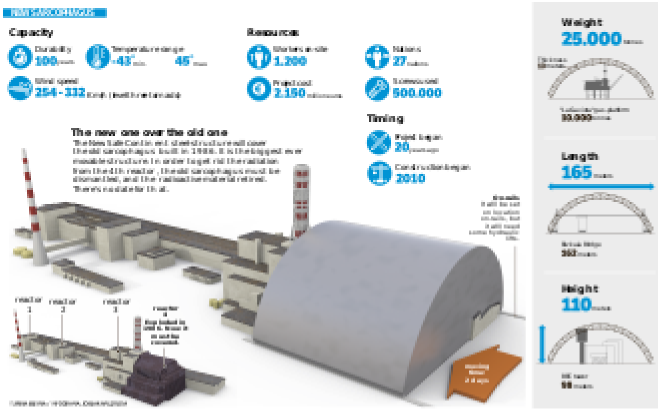
Legacy shelter

The original shelter formally referred to as the *Object Shelter* and often called *the sarcophagus*, was constructed between May and November 1986 as an emergency measure to contain the radioactive materials within reactor Unit 4 at the Chernobyl nuclear power plant (ChNPP). The shelter was constructed under extreme conditions, with very high levels of radiation, and under extreme time constraints. The Object Shelter was moderately successful in containing radioactive contamination and providing for post-accident monitoring of the destroyednuclear reactor unit.

The existing Object Shelter is primarily supported by the damaged remains of the Unit 4 Reactor Building which are largely considered to be structurally unsound as a result of explosive forces caused by the accident. Three major structural members support the roof of the Object Shelter. Two beams, usually referred to as B-1 and B-2, run in an east-west direction and support the roof beams and panels. A third, more massive member, the "Mammoth Beam", spans the largest distance across the roof from east to west and assists in supporting the roof beams and panels. The roof of the shelter itself consists of 1 metre (3 ft 3 in) diameter steel pipes laid horizontally north to south, and steel panels that rest at an angle, also in the north-south direction.

Design and construction

The south wall of the Object Shelter is formed by the steel panels of the roof as they make an angle of approximately 15 degrees from vertical. The east wall of the shelter is formed by the reactor building itself, and the north wall by a combination of the reactor building and concrete segments. The west wall is constructed of large concrete sections reinforced by buttresses. The complexity of the segments of the west wall necessitated their construction off-site; they were then lifted into place by a remotely operated tower crane. It is these buttressed sections of the Object Shelter that are most often recognized in photographs of the sarcophagus.



Infographic about the construction process of The New Safe Confinement at Chernobyl Nuclear Power Plant

The Object Shelter was never intended to be a permanent containment structure, despite rumors to the contrary. Its continued deterioration has increased the risk of its radioactive inventory leaking out into the environment. Between 2004 and 2008, workers stabilized the roof and western wall of the shelter. However, construction of the NSC was necessary in order to continue containing the radioactive remains of ChNPP reactor 4. Further upgrades to the area in preparation for NSC construction were completed in 2010 and included road and rail connections, site services (power, water, drains, and communications), facilities for workers (including medical and radiation protection facilities), and the installation of a long-term monitoring system.[5] It has been estimated that up to 95% of the original radioactive inventory of reactor Unit 4 still remains inside the ruins of the reactor building.[6]

International competition

In 1992, Ukraine's government held an international competition for proposals to replace the sarcophagus.[7]

In the autumn of 1992, Design Group Partnership (DGP) of Manchester was invited to assist the Atomic Energy Authority (AEA) for the UK's submission for the international competition organized by the Ukrainian government.

DGP's senior management was assembled to generate a solution. David Haslewood suggested an arch, built off-site, and then slid over the existing Soviet-built sarcophagus because:

1. Off-site construction would minimize radiation doses of construction workers.
2. An arch would fit snugly over the damaged reactor excluding its chimney
3. An arch would be easier to slide than a square box.

Of the 394 entries, only the British submission proposed a sliding arch approach.[8] There was no top design choice, but the French submission came as 2nd best with the UK and German proposals coming joint 3rd.

Subsequently, a pan-European study (the TACIS programme) re-examined the proposals of the top three finalists of the competition. The study selected the sliding arch proposal as the best solution for their further investigations and recommendations, primarily to reduce the chance of the construction workers receiving a harmful dose of radiation.

On 17 September 2007 Vinci Construction Grands Projets and Bouygues Travaux Publics announced that they won the contract to build the New Safe Confinement as 50/50 partners of a French consortium named Novarka. The original 432 million euros contract comprises the design and construction of the NSC and planned to employ 900 people at its peak.[2]

Design goals

The New Safe Confinement (NSC) was designed with several design goals in mind:

- Convert the destroyed ChNPP Unit 4 into an environmentally safe system (i.e. contain the radioactive materials at the site to prevent further environmental contamination).
- Reduce corrosion and weathering of the existing shelter and the Unit 4 reactor building.
- Mitigate the consequences of a potential collapse of either the existing shelter or the Unit 4 reactor building, particularly in terms of containing the radioactive dust that would be produced by such a collapse.
- Enable safe demolition of unstable structures (such as the roof of the existing shelter) by providing remotely operated equipment for their demolition.
- Qualify as a Nuclear entombment device.

New Structural design

The NSC design is an arch-shaped steel structure with an internal height of 92.5 metres (303.5 ft) and a 12-metre (39.4 ft) distance between the centers of the upper and lower arch chords. The internal span of the arch is to be 245 metres (803.8 ft), and the external span is to be 270 metres (885.83 ft). The dimensions of the arch were determined based upon the need to operate equipment inside the new shelter and decommission the existing shelter. The overall length of the structure is 150 metres (492.1 ft), consisting of 13 arches assembled 12.5 metres (41 ft) apart to form 12 bays. The ends of the structure will be sealed by vertical walls assembled around, but not supported by the existing structures of the reactor building.

The arches are constructed of tubular steel members and are externally clad with three-layer sandwich panels. These external panels will also be used on the end walls of the structure. Internally, each arch will be covered in polycarbonate (Lexan) to prevent the accumulation of radioactive particles on the frame members themselves.

Large parts of the arches will be shop-fabricated and transported to the assembly site 180 metres (590 ft) west of reactor Unit 4. Each of the steel tubes will be high-strength steel in order to reduce cost and assembly weight. The steel used in construction of the tubular members will have a yield strength of no less than 2,500 kg/cm^2 (250 MPa; 36,000 psi).

Warm, dry air will be circulated in the gap between inner and outer roof sections in order to prevent corrosion and to stop drops of condensation falling into the interior.[9]

Foundation design

The foundations of the NSC must meet the primary design requirements:

- They must support the weight of the arches of the NSC.
- They must support rail tracks across which the NSC can roll 180 metres (590 ft) from the construction site into place over Unit 4.
- They must minimize the amount of digging and cutting into the upper layers of the ground, as the upper soil is heavily contaminated with nuclear material from the disaster.

The site of the NSC itself is slightly sloped, ranging in elevation from +117.5 metres (385 ft) on the eastern side to +144 metres (472 ft) on the western side. The foundation must account for this difference without extensive site levelling.

The ground upon which the foundation must be built is unique in that it contains a "technogenic layer" just below the surface that is approximately 2.5 to 3 metres (8 to 10 ft) in overall depth. The technogenic layer was created by radioactive contamination from the accident and consists of various materials including nuclear material, stone, sand, loamy sands, concrete (probably unreinforced), and construction wastes. It is considered unfeasible to determine the geotechnical characteristics of this soil layer. As a result of this, no assumptions about the load-bearing properties of the technogenic layer were made during the design of the foundation.

The water table at ChNPP fluctuates from +109.9 metres (360.6 ft) on average in December to +110.7 metres (363.2 ft) on average in May.

Several options were considered for the foundation design for the NSC. Ultimately, the final design was specified as consisting of three lines of two 4.50-by-1.00-metre (14.76 by 3.28 ft) foundation panels 21 metres (68.9 ft) in length and a 4-metre (13.1 ft) high pile cap that reaches to a height of +118 metres (387 ft) of elevation. This option was selected in order to minimize the cost of the foundation, the number of cuts into radioactive soil layers, dose uptake of workers, and risk to the environment from further contamination. The foundation has a slight difference between the area in which the NSC will be constructed and the final resting area around Unit 4.

Special consideration is necessary for the excavation required for foundation construction due to the high level of radioactivity found in the upper layers of soil. The use of rope operated grabs for the first 0.3 metres (11.8 in) of pile excavation has been recommended for the Chernobyl site by the conceptual designers of the NSC. This will reduce the direct exposure of workers to the most contaminated sections of the soil. Deeper excavation for the foundation piles will be accomplished using hydraulic clam shells operated under bentonite slurry protection.

The foundation is designed to withstand horizontal acceleration structural loads of up to 0.08 g, as well as to withstand an F3 tornado. The original design for the structure required it to withstand an F1 tornado until an independent beyond-design-basis analysis was carried out to evaluate the effects of an F3 tornado upon the structure.

Assembly process

The NSC was assembled in the following steps:

1. Stabilization of the Object Shelter in order to prevent collapse during construction.
2. Excavation and construction of the foundation.
3. Assembly of first and second arches to form Bay 1, installation of east wall on arch 1.
4. Bay 1 will be slid East to accommodate the construction of arch 3 and Bay 2.
5. Subsequent sliding of the complete structure and adding of arches and Bays to complete the structure.

6. Installation of cranes and large maintenance equipment.
7. Installation of the west wall.
8. Final slide into place over Unit 4 (29 November 2016).[3]
9. Deconstruction of the fragmentation, decontamination, and auxiliary buildings.

This process of assembly was deemed advantageous because it took advantage of the designed mobility of the structure to maximize the distance between workers and the reactor building, thereby minimizing their exposure to radiation.

As each bay was completed, infrastructure equipment - including that for ventilation systems, radiation monitoring, plumbing, and electrical was installed.

Positioning

The NSC was constructed 180 metres (590 ft) west of Unit 4, and slid into place. The actual sliding of the structure along foundation rails was a difficult process. The system used in the construction of the NSC derived from civilian bridge launching and bridge cantilever methods.

Two options were initially considered for moving the structure: hydraulic jacks to push the structure forward, or pulling the structure with large, multi-stranded steel cables. The first option would require the relocation of the hydraulic jacks after each push. This relocation process would necessitate more worker interaction with the system and a greater worker exposure to radiation. The second option was initially chosen because it would expose workers to a lower radiation dose, and would have moved the structure into its final position in less than 24 hours. However, the structure was moved using hydraulic jacks making the 327-meter move starting on 14 November 2016 and ending on 29 November.[3][10]

The EBRD has described the arch as the largest moveable land-based structure ever built.[10][11]

Demolition of existing structures

The final phase of construction of the NSC involves the demolition of the unstable structures associated with the original Object Shelter ("Sarcophagus"). The goal of demolition has imposed significant requirements upon the load carrying capacity of the arches and foundation of the NSC, as these structures must carry the weight of not only the suspended cranes to be used in demolition, but also loads of those cranes.

Demolition equipment

The NSC design includes two bridge cranes suspended from the arches. These cranes travel east to west on common runways and each has a span of 84 metres (276 ft).

Each crane can carry a variety of interchangeable carriages. Three types of carriages have been designed for the NSC:

- One typical lifting carriage with a 50-tonne (55-ton) carrying capacity.
- One secure lifting carriage for shielded transportation of personnel, with a 50-tonne (55-ton) carrying capacity.
- One carriage suspends a mobile tool platform, extending up to 75 metres (246 ft), that can be fitted with a variety of end actuators useful for demolition.

The cranes' carriage interchangeability allows the rotation of the largest members to be demolished, reducing the overall size of the NSC by approximately one arch bay

After the members to be demolished are removed by crane they must be fragmented into pieces small enough to decontaminate. It is expected that the primary contamination of most demolished elements will be loose surface contamination (mostly dust) and can largely be removed. Decontamination will take place using vacuum cleaners with HEPA filters, grit blasting (for steel elements), and scarifying (for concrete elements). Once decontaminated to the maximum extent practical, pieces will be further fragmented for eventual disposal. Fragmentation tools include plasma arc cutting torches, diamond circular cutting wheels, and diamond wire cutting. The tools selected for the demolition process were selected upon the basis of a number of factors, including minimization of individual and collective radiation exposure, the amount of secondary waste generated, the feasibility of remote operation, the cutting efficiency, fire safety, capital cost and operating costs.

The exact methods for disposing of wastes generated by the demolition process have not yet been determined and may include on-sit burial outside the NSC for low-level waste, and long-term storage inside the NSC for medium and high-level wastes. At this time no policy has been made as to the disposal and processing of fuel containing materials

Elements to be demolished

The following elements of the Object Shelter are planned for demolition:

Element	Quantity	Mass of each (metric tons)	Length of each (meters)	Length of each (feet)
Southern roof flat panels	6	31	28.7	94.2
Southern roof flat panels	6	16	28.7	94.2
Southern hockey stick panels	12	38	25.5	83.7
Mammoth beam	1	127	70	229.7
Northern beam B1	1	65	55	180.4
Southern beam B1	1	65	55	180.4
Northern hockey stick panels	18	9	18	59.1
Eastern hockey stick panels	1	7.25	7	23.0
Light roof	6	21	36	118.1
Piping roof	27	20	36	118.1
Northern beam B2	1	57	40	131.2
Southern beam B2	1	57	40	131.2
TOTALS:	**85 elements**	**1944.25 tons**	**439.9 meters**	**1443.2415 feet**

Types of materials to be demolished

The elements that are to be demolished fall into several broad material types:

- Steel
  - Flat (roof panels)
  - Three-dimensional (pipes, trusses, beams)
- Reinforced concrete
  - Pre-cast
  - Cast in place
- Debris
  - Fragments of steel structures and equipment
  - Fragments of reinforced concrete structures
  - Materials added after the Chernobyl accident to mitigate its consequences.

Waste storage

Near to the Chernobyl site, the Vector Radioactive Waste Storage Facility[12] is being built, consisting of the Industrial Complex for Solid Radwaste Management (ICSRM),[13] a nuclear waste storage site. It is being constructed by Nukem Technologies, a German nuclear decommissioning company which is a subsidiary of the Russian Atomstroyexport. This storage is reported to be able to contain 75,000 cubic meters.[14][15] The storage is both for (temporary) high level waste as well as low and intermediate level waste storage.[16][17]

Project status

Planned schedule

The New Safe Confinement (NSC) was originally intended to be completed in 2005, but the project has suffered lengthy delays. In June 2003 the projected completion date was slated for February 2008, according to the following schedule:

- 12 February 2004 - complete the NSC conceptual design
- 13 March 2004 - Government of Ukraine to approve the conceptual design
- 13 June 2004 through 13 September 2004 - conduct a tender and sign a contract with the winner to proceed with relevant engineering and construction work
- 16 April 2006 through 20 May 2007 - lay foundations for the NSC
- 16 April 2006 through 22 October 2007 - fabricate steel arch segments, assemble, move in contact and secure arch sections
- 23 October 2007 through 19 February 2008 - install cranes, piping and lighting fixtures under the arch
- 20 February through 29 February 2008 - slide the arch structure in place over the existing Shelter

(The actual sliding took place in the second half of November 2016.)

In 2009, planned completion was projected for 2012; the same year, progress was made with stabilization of the existing sarcophagus, which was then considered stable enough for another 15 years. In February 2010 the reported completion date of the NSC was pushed back to 2013.[18] As of April 2011, the estimated completion date has been updated to Summer 2015.[4] In November 2016, the planned completion date was stated as November 2017.

The project has involved workers and specialists from at least 24 countries in addition to Ukraine.[19]

Timeline

March 2004
: An international tender for NSC design and construction was announced. Two bid candidates were identified, but in September 2006 the plant's general director Ihor Hramotkyn announced his intent to annul all bids on the project.[20]

17 September 2007
: The project contract was finally signed, with French consortium Novarka (consisting of Vinci Construction Grands Projets and Bouygues Construction as 50/50 partners) constructing the 190 by 200 meter arch structure. Construction costs were estimated at $1.4bn with a project time of five years.[21] The constructing consortium itself reported slightly different numbers, mentioning a contract of €432 million, and dimensions of 150 meters length, 257 meters span and 105-meter height. The estimated time for completion was given as 53 months, including 18 months of planning and design studies, with a projected completion in mid-2012.[2]

February 2010
: The Director-General of the plant's facility administration projected completion of the NSC in 2013;[18] Novarka began construction in September 2010.[22]

8 April 2011
: Updates from the European Bank for Reconstruction and Development (EBRD) stated the NSC would be assembled by "summer 2015 and subsequently be slid over the present shelter", with an updated cost of completion estimated at €1.54bn, and a funding shortfall of €600m.[4]

April 2011

Some project milestones, including infrastructure and preparatory work such as the NSC pilings, were completed.[4]

April 2012

Steel erection began.[23]

26 November 2012

The first sections were raised.[24][25]

24 May 2013

The metal arch structure of the eastern arch was near completion. The interior systems including ductwork and dismantling cranes were under construction. The exterior paneling was also being added to the second section and was at 79% completion.[26]

13 June 2013

The second lifting operation on the eastern arch was performed.

April 2014

The fully lifted eastern arch was moved 112 meters eastward on its rails to a parking position to clear the construction area for building the western arch.

4 August 2014

The western arch completed the second of three "lifting" operations which raise the height of the arch.

12 November 2014

Successfully completed the 3rd ascent of the western part arches.

April 2015

The two arches were fused, and the west wall was under construction. Internal completion was ongoing.

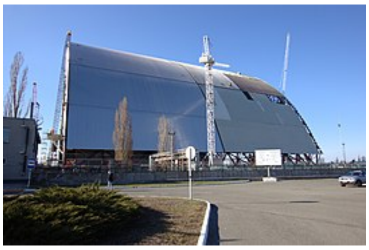
April 2016

Construction of the arches was completed.[27]

The New Safe Confinement (NSC) under construction in 2013

A panorama view of the Chernobyl Nuclear Power Plant in June 2013. The NSC construction area is the arch on the left-hand side

The NSC under construction in April 2015



Construction in April 2015

Construction in March 2016

The NSC nearing completion in October 2016

Nearing completion in October 2016

14 November 2016

The arch was slipped over the existing sarcophagus over the course of five days.[10]

29 November 2016

The NSC slipping was completed, taking a total of fifteen days.[28] It was pushed on teflon pads by hydraulic pistons, guided by lasers.[29]

November 2017

Development company Rodina started the construction on the first PV project to be developed within the Chernobyl exclusion zone. 3,762 solar modules would be installed at the site with a generation capacity of 1MW. The solar installation was expected to commence operations in the fourth quarter of 2017.[30]

December 2017

According to a project official, construction completion will be delayed until May 2018 due to a contractor being unable to finish its works in time.[31] The reason is the extremely high level of radiation, forcing workers to limit their presence at the site to a minimum.[32]

NSC placed over reactor four of Chernobyl nuclear power plant as of September 2017, with the monument to the constructors of the sarcophagus in the foreground

Responsible organizations

The European Bank for Reconstruction and Development (EBRD) is responsible for managing the Shelter Implementation Plan, including overseeing the construction of the New Safe Confinement.[33]

Worker safety and radioactive exposure

Radioactive dust in the shelter is monitored by hundreds of sensors.[9] Workers in the 'local zone' carry two dosimeters, one showing real-time exposure and the second recording information for the worker's dose log.[23]

Workers have a daily and annual radiation exposure limit. Their dosimeter beeps if the limit is reached and the worker's site access is canceled.[23] The annual limit (20 millisieverts) may be reached by spending 12 minutes above the roof of the 1986 sarcophagus, or a few hours around its chimney.[19]

See also

- List of nuclear and radiation accidents

References

Notes

1. "Chernobyl's New Safe Confinement" (http://www.ebrd.com/what-we-do/sectors/nuclear-safety/chernobyl-new-safe-confinement.html). *European Bank for Reconstruction and Development*. Retrieved 31 May 2018.
2. "Vinci and Bouygues sign contract to build Containment Shelter for the Chernobyl Sarcophagus" (https://web.archive.org/web/20111002175055/http://www.bouygues.com/document/?f=press-room%2Fen%2Fbouyguesconstruction_chernobylsarcophagus_17092007_us.pdf) (PDF). Archived from the original (http://www.bouygues.com/document/?f=press-room/en/bouyguesconstruction_chernobylsarcophagus_17092007_us.pdf) (PDF) on 2 October 2011. Retrieved 19 April 2011.
3. "Unique engineering feat concluded as Chernobyl arch has reached resting place" (http://www.ebrd.com/news/2016/unique-engineering-feat-concluded-as-chernobyl-arch-has-reached-resting-place.html). *European Bank for Reconstruction and Development*. 29 November 2016. Retrieved 12 January 2018.
4. Reiserer, Axel (8 April 2011). "NOVARKA and Chernobyl Project Management Unit confirm cost and time schedule for Chernobyl New Safe Confinement" (https://web.archive.org/web/20110918032131/http://www.ebrd.com/pages/news/press/2011/110408e.shtml). *European Bank for Reconstruction and Development*. Archived from the original (http://www.ebrd.com/pages/news/press/2011/110408e.shtml) on 18 September 2011. Retrieved 16 August 2011.
5. "Chernobyl 25 years on: New Safe Confinement and Spent Fuel Storage Facility" (http://www.ebrd.com/downloads/research/factsheets/chernobyl25.pdf) (PDF). *European Bank for Reconstruction and Development*. January 2011. Retrieved 2 March 2018.
6. Vidal, John (19 April 2011). "Ukraine raises $785m to seal Chernobyl under new 'shell'" (https://www.theguardian.com/environment/2011/apr/19/ukraine-funding-chernobyl-arch). *The Guardian*. Retrieved 2 March 2018.
7. International Competition, 1992 - Ukraine Government
8. Smith, Stuart; Lacombe, Herve (February 1997). "A second shelter for Chernobyl: Its necessity and feasibility". *Proceedings of the Institution of Civil Engineers*. **120** (1): 2–14. doi:10.1680/icien.1997.29157 (https://doi.org/10.1680%2Ficien.1997.29157).
9. Excell, John (11 February 2013). "Building Chernobyl's New Safe Confinement" (http://www.theengineer.co.uk/in-depth/the-big-story/building-chernobyls-new-safe-confinement/1015479.article). *The Engineer*.
10. "Chernobyl disaster: Giant shield begins move towards reactor" (http://www.bbc.co.uk/news/world-europe-37978482). *BBC News*. 14 November 2016. Retrieved 30 November 2016.
11. Borys, Christian (3 January 2017). "A vast new tomb for the most dangerous waste in the world" (http://www.bbc.com/future/story/20170101-a-new-tomb-for-the-most-dangerous-disaster-site-in-the-world). *BBC Future Now*. Retrieved 2 March 2018.
12. "News" (https://web.archive.org/web/20110720161210/http://www.delukr.ec.europa.eu/press_releases.html?id=47113). *Delegation of the European Union to Ukraine*. Archived from the original (http://www.delukr.ec.europa.eu/press_releases.html?id=47113) on July 20, 2011. Retrieved July 31, 2008.
13. "Industrial Complex For Solid Radwaste Management (ICSRM) at Chernobyl Nuclear Powerplant" (http://www.nukemgroup.com/fileadmin/user_upload/Chernobyl_Ukraine_Mai2008.pdf) (PDF). *Nukem Technologies*. May 2008. Retrieved 31 July 2008.
14. Gache, Gabriel (25 April 2008). "Chernobyl Receives Nuclear Waste Processing Complex" (http://news.softpedia.com/news/Chernobyl-Receives-Nuclear-Waste-Processing-Complex-84344.shtml). *Softpedia.com*.

15. "Nuclear waste storage inaugurated in Chernobyl" (https://web.archive.org/web/20080724123431/http://www.eubusiness.com/news-eu/1208978222.51/). *EU Business*. Archived from the original (http://www.eubusiness.com/news-eu/1208978222.51/) on July 24, 2008.
16. Tokarevskyi, O.; Alekseeva, Z.; Kondratiev, S.; Rybalka, N. (November 2013). *Safety issues in construction of facilities for long-term storage of radioactive waste at Vector site* (https://www.eurosafe-forum.org/sites/default/files/Eurosafe2013/Seminar%202/2.07_Safety_Issues_Construction_Facilities_Vector_Site_SSTC_SNRIU_Paper.pdf) (PDF). Eurosafe Forum 2013 (https://www.eurosafe-forum.org/eurosafe2013#Seminar_2). Cologne, Germany. inis..RN:45021661 (https://inis.iaea.org/search/search.aspx?orig_q=RN:45021661). Retrieved 12 January 2018.
17. Lee, William E.; Ojovan, Michael I.; Jantzen, Carol M. (31 October 2013). *Radioactive Waste Management and Contaminated Site Clean-Up: Processes, Technologies and International Experience* (https://books.google.com/books?id=0HRHAgAAQBAJ&lpg=PA404&pg=PA406#v=onepage&q=Vector+Radioactive+Waste+Storage+iaea&f=false). Elsevier Science. pp. 404–406. ISBN 978-0-85709-744-6.
18. "Chernobyl New Safe Confinement - New Completion Date Announced" (https://web.archive.org/web/20110708142609/http://www.chernobylee.com/blog/2010/02/chernobyl-new-safe-confinement.php). *Chernobyl and Eastern Europe*. 15 February 2010. Archived from the original (http://www.chernobylee.com/blog/2010/02/chernobyl-new-safe-confinement.php) on 8 July 2011. Retrieved 16 March 2011.
19. Meo, Nick (26 November 2013). "Chernobyl's arch: Sealing off a radioactive sarcophagus" (http://www.bbc.co.uk/news/magazine-25086097). *BBC News*.
20. "Ukraine may hold new tenders on Chernobyl safety facility" (http://www.accessmylibrary.com/article-1G1-152004040/ukraine-may-hold-new.html). *BBC Monitoring International Reports*. 27 September 2006.
21. "Chernobyl to be covered in steel" (http://news.bbc.co.uk/1/hi/world/europe/6999140.stm). *BBC News*. 18 September 2007. Retrieved 20 May 2010.
22. "Work begins on new sarcophagus for Chernobyl reactor" (http://www.nuclearpowerdaily.com/reports/Work_begins_on_new_sarcophagus_for_Chernobyl_reactor_999.html). *Nuclear Power Daily*. 24 September 2010. Retrieved 16 March 2011.
23. Hankinson, Andrew (3 January 2013). "Containing Chernobyl: the mission to defuse the world's worst nuclear disaster site" (https://www.wired.co.uk/magazine/archive/2012/12/features/containing-chernobyl?page=all). *Wired*.
24. "Workers raise first section of new Chernobyl shelter" (http://www.3news.co.nz/Workers-raise-first-section-of-new-Chernobyl-shelter/tabid/1160/articleID/278425/Default.aspx). *3 News*. Associated Press. 28 November 2012.
25. Heintz, Jim (17 November 2012). "Workers raise 1st section of new Chernobyl shelter" (https://web.archive.org/web/20130120100343/http://bigstory.ap.org/article/first-section-new-shelter-chernobyl-ready). Associated Press. Archived from the original (http://bigstory.ap.org/article/first-section-new-shelter-chernobyl-ready) on 20 January 2013. "Workers have raised the first section of a colossal arch-shaped structure that eventually will cover the exploded nuclear reactor at the Chernobyl power station".
26. Tatyana, Hryva. "Chornobylʹsʹka AES" (http://www.chnpp.gov.ua/index.php?option=com_content&view=article&id=417/). *chnpp.gov.ua* (in Ukrainian).
27. "$1.7B Giant Arch to Block Chernobyl Radiation For Next 100 Years" (http://www.nbcnews.com/tech/tech-news/17b-giant-arch-block-chernobyl-radiation-next-100-years-n544721). *NBC News*. Reuters. 24 March 2016. Retrieved 20 November 2016.
28. "Unique engineering feat concluded as Chernobyl arch has reached resting place" (http://www.ebrd.com/news/2016/unique-engineering-feat-concluded-as-chernobyl-arch-has-reached-resting-place.html) (Press release). European Bank for Reconstruction and Development. 29 November 2016. Retrieved 30 November 2016.
29. "Chernobyl New Safe Confinement: a one-of-a-kind project" (https://www.vinci.com/vinci/actualites.nsf/8BBA50CC6F1891E8C1258079005011BA/$File/VINCI_PV_Dossier_de_presse_Tchernobyl_GB.pdf) (PDF). *Vinci SA*. 29 November 2016. p. 21. Retrieved 2 March 2018.
30. "Rodina begins construction on first PV project inside Chernobyl exclusion zone" (https://www.pv-tech.org/news/rodina-begins-construction-on-first-pv-project-inside-chernobyl-exclusion-z). *PV Tech*. Retrieved 17 November 2017.
31. "Ukraine postpones Chernobyl reactor safety cover" (http://news.xinhuanet.com/english/2017-12/07/c_136806475.htm). *Xinhua News Agency*. Retrieved 20 November 2017.
32. Seidler, Christoph (20 December 2017). "Strahlung zu hoch: Fertigstellung des Tschernobyl-Sarkophags verzögert sich" (http://www.spiegel.de/wissenschaft/mensch/tschernobyl-fertigstellung-des-sarkophags-verzoegert-sich-a-1184230.html). *Spiegel Online* (in German). Retrieved 20 December 2017.

33. Onishi, Yasuo; Voitsekhovich, Oleg V.; Zheleznyak, Mark J. (3 June 2007). *Chernobyl - What Have We Learned?: The Successes and Failures to Mitigate Water Contamination Over 20 Years* (https://books.google.com/books?id=AKTjYeWO5E0C&pg=PA248). Springer Science & Business Media. p. 248. ISBN 978-1-4020-5349-8.

Further reading

- Schmieman, Eric; Wrona, Matthew; et al. (2004). *Conceptual Design of the Chornobyl New Safe Confinement — An Overview* (PDF). Pacific Basin Nuclear Conference. Archived from the original (PDF) on 4 June 2011.
- "Chornobyl: Five-Year Schedule set for New Safe Confinement Over Wrecked Unit". 9 June 2003. Archived from the original on 14 February 2008.
- *Project Implementation Phase 2* from *Chernobyl Nuclear Power Plant*
- *SIP Project Summary Document* from *The European Bank for Reconstruction and Development*

External links

- Official website: Chernobyl Nuclear Power Plant (CNPP)
- Description of the New Safe Confinement. Design of the new protective shield under Sarcophagus.
- Chernobyl 25 years on on YouTube, European Bank for Reconstruction and Development. Computer rendered video of the construction process, Novarka, October 2009
- November 2014, Chernobyl Story on CBS 60 Minutes
- NSC site live camera
- Unique engineering feat concluded as Chernobyl arch has reached resting place on YouTube showing of NSC being slid into position, 14–29 November 2016, European Bank for Reconstruction and Development channel

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