Abstract

Chernobyl NPP decommissioning efforts. Past, Present and Future.

Viktor Kuchinskiy Chernobyl NPP, Ukraine
Tel.: +380(4579) 4 44 05
e-mail: kvk@chnpp.gov.ua

Two unique large-scale projects are underway at the moment within the Chernobyl Exclusion zone – Shelter object transformation into ecologically safe system and decommissioning of three Chernobyl NPP Units.

As a result of beyond design accident in 1986 the entire territory of the industrial site and facilities located on it was heavily contaminated. Priority measures were carried out at the damaged Unit under very difficult conditions to reduce the accident consequences and works to ensure nuclear and radiation safety are continuous, and the Unit four in 1986 was transformed into the Shelter object. Currently, works at the Shelter object are in progress. Under assistance of the International Community new protective construction was built above the existing Shelter object - New Safe Confinement, which will ensure the SO Safety for the long term – within up to 100 years.

Strategy of Shelter object Transformation into environmentally safe system

1998 2008 2017 2117

Phase 1: stabilization of existing object status
Phase 2: creation of the additional protective barriers
Phase 3: Fuel Containing Materials and Long Lived RAW retrieval from SO

The second major project is the simultaneous decommissioning of Chernobyl NPP Units 1, 2 and 3. Currently existing Chernobyl NPP decommissioning Strategy has been continuously improved starting from the Concept of 1992. Over the years the following was analyzed and taken into account: the results of numerous R&D works, international experience in decommissioning, IAEA recommendations, comments and suggestions from the governmental and regulatory bodies in field of nuclear energy use and Radioactive Waste Management.

In 2008 the final decommissioning strategy option for Chernobyl NPP was approved, that was deferred gradual dismantling – SAFSTOR. In accordance with this strategy, decommissioning will be carried out in three stages (Final Shutdown and Preservation, Safe Enclosure, Dismantling). Deferred gradual dismantling - SAFSTOR stipulates:

Preservation of the reactor, the primary circuit and the reactor compartment equipment;
Dismantling of the equipment external in relation to the reactor;
Safe enclosure (under the supervision);
Gradual dismantling of the primary circuit and reactor (after 50 years);
Site cleaning up to the established levels.

Deecommissioning strategy of Chernobyl NPP Units 1, 2 and 3

At the moment Chernobyl NPP is at the Final Shutdown and Preservation stage. Permission for this stage implementation was obtained in 2015 after Spent Nuclear Fuel complete removal from the Units. The main task of this stage is reactors preparation to the long-term safe enclosure under supervision.

Chernobyl NPP Decommissioning Strategy determines the final state of the Chernobyl NPP industrial site as "industrially developed site", integrated in the nuclear industrial complex of Ukraine, used the developed Chernobyl NPP’s infrastructure and personnel capabilities. From radiological point of view, taking into account Exclusion zone specificity, the final state was established as "brown spot".
Decommissioning Efforts on Chornobyl NPP site – Past, Present and Future Activities

Viktor Kuchynskyi - Chernobyl NPP, Ukraine,
Phone:  +380(4579) 4 44 05
e-mail:  kvk@chnpp.gov.ua
Mitigation of Chernobyl NPP accident

The worst world accident in the nuclear power history occurred at Unit 4 of Chernobyl NPP on April 26, 1986.

- The 7th level of the INES scale was assigned to the accident
- About 50 MCI of radioactivity was released within 10 days
- 200,000 square kilometers were contaminated

In the first days after the accident, all activities were aimed on three major hazards preventing.

**Nuclear hazard** is occurrence of a self-sustaining chain reaction

**Thermal hazard** is possibility of formation of high-temperature (2000 °C) melt of core materials. This melt can burn a unit structure and reach the ground waters.

**Radiation hazard** is a release of radioactivity into the environment and high radiation background.
Early stage actions for Chernobyl accident elimination

Measures performed at early stage of the accident:
• Evacuation of general public from Pripyat and surrounding area (April 27-29)
• Plugging of the reactor from helicopters - until May 10,
• Construction of the under foundation plate (May-June)
• Organization of the 30 km Exclusion Zone
• Decontamination of the area close to emergency unit (May-July)
• Decontamination of the Unit 3 roof and the others facilities (August - December)
• Designing, construction and commissioning of the Shelter (June- November)
Top filling (plugging) of the reactor

To reduce releases from the destroyed reactor to the environment, Governmental Commission decided to drop materials from helicopters into the reactor shaft.

<table>
<thead>
<tr>
<th>Name of the material</th>
<th>Chemical formula</th>
<th>weight (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron carbide</td>
<td>B₄C</td>
<td>40</td>
</tr>
<tr>
<td>Dolomite</td>
<td>MgCa(CO₃)₂</td>
<td>1200</td>
</tr>
<tr>
<td>Crushed marble, clay, sand, etc.</td>
<td>-</td>
<td>3500</td>
</tr>
<tr>
<td>Lead (fractions + “bars” and others)</td>
<td>Pb</td>
<td>6700</td>
</tr>
<tr>
<td>Trisodium phosphate (solution)</td>
<td>Na₃P0₄</td>
<td>2500</td>
</tr>
<tr>
<td>Other dust suppression compositions (solutions).</td>
<td>Latex type CKC-65 gp, bard, liquid glass, silicon rubber, etc.</td>
<td>2700</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>16600</td>
</tr>
</tbody>
</table>
Dynamics of releases

After the first powerful release of radioactivity caused by the reactor explosion, release of radioactivity has not stopped.

The intensity of the release, mCi/day. The limit of uncertainty for all releases was ± 50%.
Arrangement of sub-foundation slab
Reducing of the radioactivity level and cleaning of the territory adjacent to the accidental Unit

The dose rate around the reactor compartment walls was 2,000 R/h and along the perimeter of Unit - 200 R/h.

Removal of reactor core fragments, removal of the top soil layer and construction of the concrete "pioneer" walls along the perimeter of the accidental unit improved significantly radiological situation.
High-Level Waste collected from the surrounding area was placed behind the "pioneering" walls.
Cleaning of the territories adjacent to the accidental Unit Trail-builder BAT-M was used for work on decontamination of the territory adjacent to the destroyed nuclear reactor. Basically BAT-M was used to remove the top layer of soil. Its weight is 27 tons.

Armoured engineering vehicle AEV played a decisive role in radioactive debris handling around the Unit 4. They are also used to cover the territory with a layer of sand, gravel, and others materials, loading and unloading of containers with radioactive waste. The vehicle was constructed on the basis of the tank T-72A and serially manufactured by IA "Uralvagonzavod" in Nizhniy Tagil.

Its weight is 60 tons.

The radiation dose reduction factor was ~ 100.
Shelter object construction and commissioning

- Construction of supports and load-bearing elements of the Shelter object covering:
  1 - Beam B1 (Beam B2 is behind it);
  2 – Pipe covering;
  3 - Upper part of the wall along the axis 50, reinforced with a "corset";
  4 - Exhausting shaft;
  5 - "Mammoth" Beam;
  6 - Western support of the "Mammoth" Beam;
  7 - Eastern support of the "Mammoth" Beam;
  8 - "Octopus" Beam.
Shelter object construction and commissioning

Construction and installation works were carried out using the unique machines and tools:

- crawler cranes «Demag» with a loading capacity on main arm up to 650 tons;
- truck cranes «Liebherr»;
- pumps for concrete mortar supplying, produced by «Schwing», «Putzmeister», «Worthington» companies;
- other machinery and equipment, refitted with remote control and protection equipment.
Structural integrity of the Shelter object

Building constructions of the Shelter object perform the function of the primary physical barrier on the way of radioactivity release in the environment.

Shelter object wasn’t created in accordance with the rules and norms of designing and construction.

Shelter object’s building constructions do not meet the requirements of normative and technical documentation on safety in parts of the structural integrity and reliability and have an undefined life time.

A complex of 8 measures (stabilization) improving durability and reliability of steel structures and building constructions was performed within the period from 1998 to 2008 to reduce the risk of the Shelter object critical structures collapse.

Implementation of stabilization measures improved the SO safety level till 2023.
Structural integrity of the Shelter object

Monitoring of building constructions condition

VISUAL INSPECTION.
The main objective is to identify cracks, shifts, distortions, damage, elements deformation, denudation of reinforcement, metal corrosion leading to reduction in strength or stability of the Shelter object supporting structures.

Subject to visual inspection:
• 17 structures erected within 1986-88. Beginning of survey -1986-88, frequency at least 1 time per year.
• 8 constructions of stabilization built within 2006-08.
• Beginning of survey -2008, frequency at least 1 time per year established by general designer
• *Performed by ChNPP personnel.*

INSTRUMENTAL MEASUREMENTS
The main objective is to monitor SO and its individual elements deformations and drawdown, identification of the horizontal and vertical movement of the control marks.

• Surveillance on the Shelter object drawdown and deformation is performed on 64 geodetic marks. Beginning of survey - 1986., frequency 1 time every quarter
• Engineering and geodesic works on the instrumental survey of reinforced concrete frame of SO deaerator stake is performed on 26 geodetic marks. Beginning of survey - 1987, frequency once per six months. GPS-technology and tools are used to ensure high accuracy.
• *Performed by specialized organization*
Sliding of the NSC in design position
Shelter Transformation Strategy

**Phase 1:** stabilization of existing object status

**Phase 2:** creation of the additional protective barriers

**Phase 3:** Fuel Containing Materials and Long Lived RAW retrieval from SO

After full removal (retrieval) of Fuel Containing Materials and Long-Lived RAW decommissioning of Shelter Object will be carried out as the final phase of transformation into ecologically safe system.

Online picture and the current status of this project can be found at: www.chnpp.gov.ua
Tentative schedule of work to transform the Shelter object into ecologically save system

- Accident Elimination, "Sarcophagus" Building
- Accident Consequences Elimination
- "Shelter" Object Stabilization
- NSC Construction
- Unstable Structures Dismantling
- Technologies Improvement and Pilot FCM Removal
- Buffer Storage
- Geological Repository Construction
- FCM Removing and Disposal
- NSC Operation
- NSC Decommissioning
ChNPP Units 1, 2, 3 Decommissioning strategy
Deferred Dismantling Strategy (SAFSTOR) is accepted for ChNPP:

- Preservation and long-term (up to 50 years) safe enclosure of the most contaminated equipment (primary circuit and reactor) under supervision
- Step-by-step dismantling of equipment – from the most “clean” to “contaminated”
- End status is “Brown spot”.

Timeline:
- 2000: Shutdown Stage
- 2015: Final Shutdown and Preservation Stage
- 2028: Safe Enclosure Stage
- 2045: Dismantling Stage
- 2064: End status

Images:
- Initial structure
- Structure after final shutdown and preservation
- Structure after safe enclosure
- Structure after dismantling
Decommissioning Infrastructure

**Complex on Manufacturing Steel Drums and Reinforced Concrete Containers for RAW Storage/Disposal** – the facility was commissioned in 2012.

**Liquid Radioactive Waste Treatment Plant** – commissioned in 2014. Processed first 3.4 m³ of liquid radioactive waste. Obtained the first 40 packages (drums) RW. 4 of them have already been transferred for disposal.

**Industrial Complex for Solid Radioactive Waste Management** – project is completed. Currently carried out the hot tests. Two of the three stages of the test was successful. The scheduled Complex commissioning – 2017.

**Interim Storage Facility for Spent Nuclear Fuel (ISF-2)** - long-term interim dry storage of spent nuclear fuel from Chernobyl NPP RMBK-1000 reactors. Design service life - 100 years.
Contractor- Holtec International, USA
Dismantling of the Unit 1 machine hall is scheduled from 2012 to 2017. Total quantity of the equipment is 13,900 tons of metal. Currently 5,300 t are dismantled by contracting organizations.

Dismantling of the Unit 2 machine hall is scheduled from 2016 to 2018. Tender procedures are undergoing now.

The premises of Unit 1 and 2 turbine hall are being planned to use for locating new RAW processing facilities and additional interim storages of RAW.
Cooling Pond Decommissioning

Main technical parameters:

• Water surface area – 22.9 km²
• Water level is 7 m higher than the water level in Pripyat river
• Annual costs for maintaining the water level ~ UAH 5 mln.

• A small cooling pond was created – that is a new source of technical water.
• Feasibility Study for the existing cooling pond decommissioning is under expert examination.
Development industrial site - final status of Chernobyl NPP

«Green field»
1992

«Brown spot»
2002

Industrially developed site
2008

Industrialy developed site is the best solution for the final status of Chernobyl NPP site decommissioning
Thank you for your attention!

Links:
www.chnpp.gov.ua