Overview of the Chernobyl Accident

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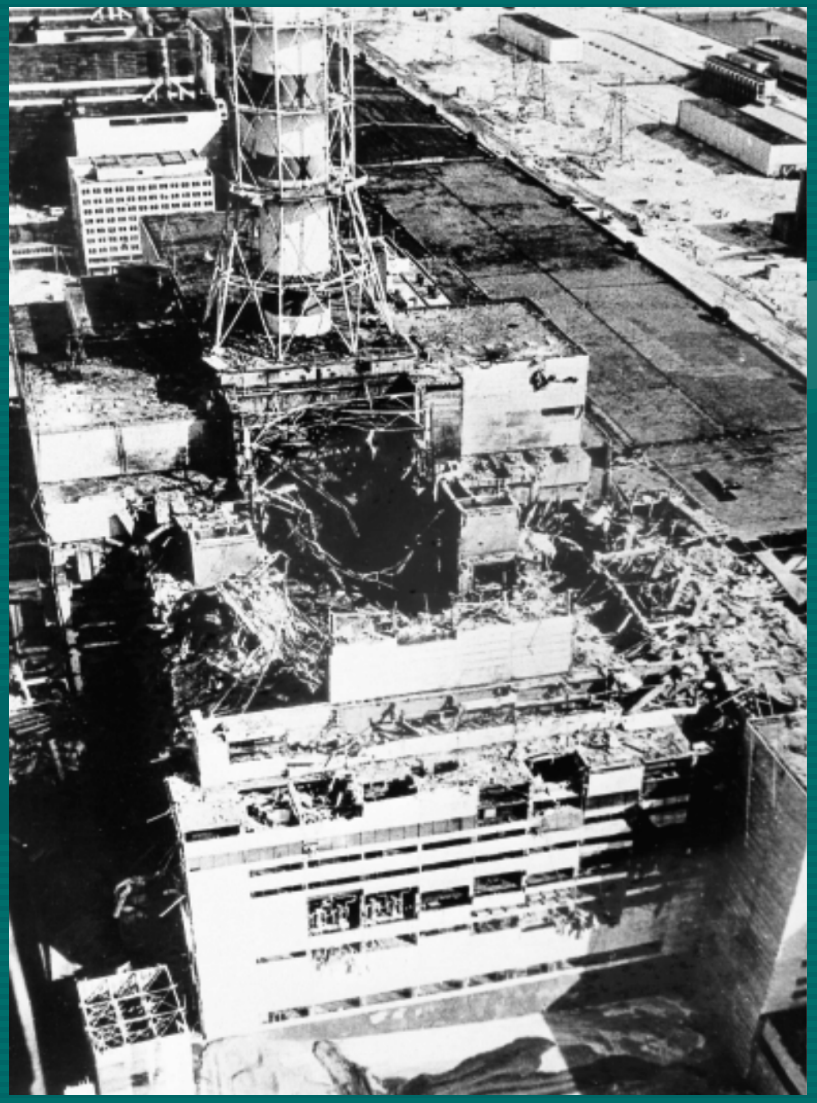
Contents

1. Cause of the accident and timeline of events
2. On-site and off-site response
3. Evacuations, KI distribution, food supply interruptions
4. Communication with neighboring countries and the rest of the world
5. Cleanup efforts the first days and first years
6. Situation today (resettlement, cleanup of the reactor and off-site)
7. Chernobyl research timeline
8. Conclusions

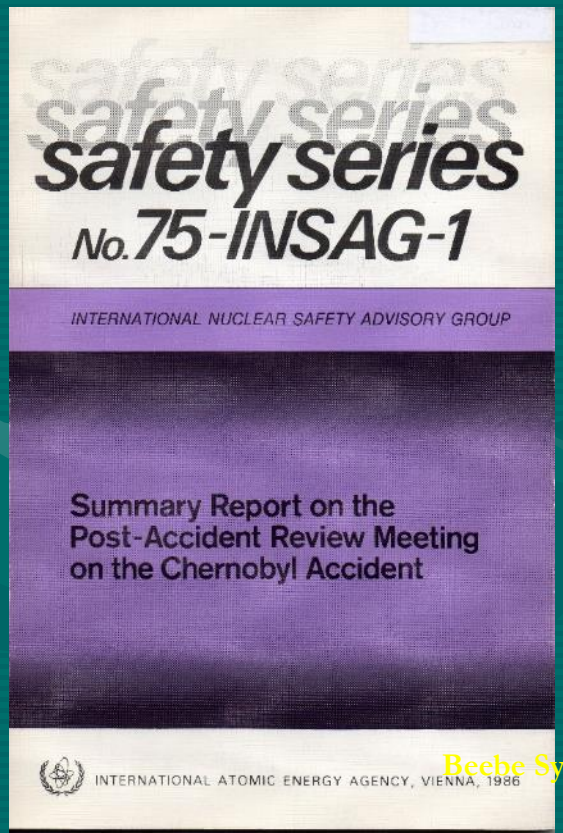
The accident

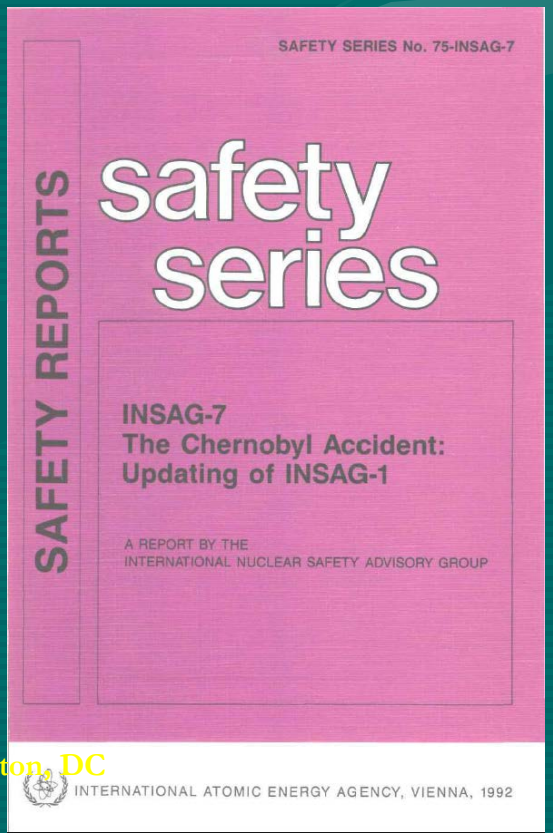
- On 26 April, 1986, at 01:23 a.m. two explosions destroyed Unit 4 of the Chernobyl NPP located 100 km N from Kiev (~2.5 mln) and just 3 km from Pripyat (~50 ths. people)
- Intensive radioactive release from red-hot core of the destroyed reactor continued for 10 days.



Cause of the accident

"…INSAG judges that factors leading to the accident are to be found in the safety features of the design, the unsatisfactory actions of the operators, and (deficiencies of) the general safety and regulatory framework" [INSAG-7, 1992]





Mitigation of the accident consequences and protective actions

– Stable iodine to Pripyat city residents; taken by ~60% pers.

–Evacuation of 115 ths. residents of the most affected areas

– Decontamination of numerous settlements

– Construction of the Shelter by November 1986

– Large scale countermeasures in agriculture, water supply and forestry

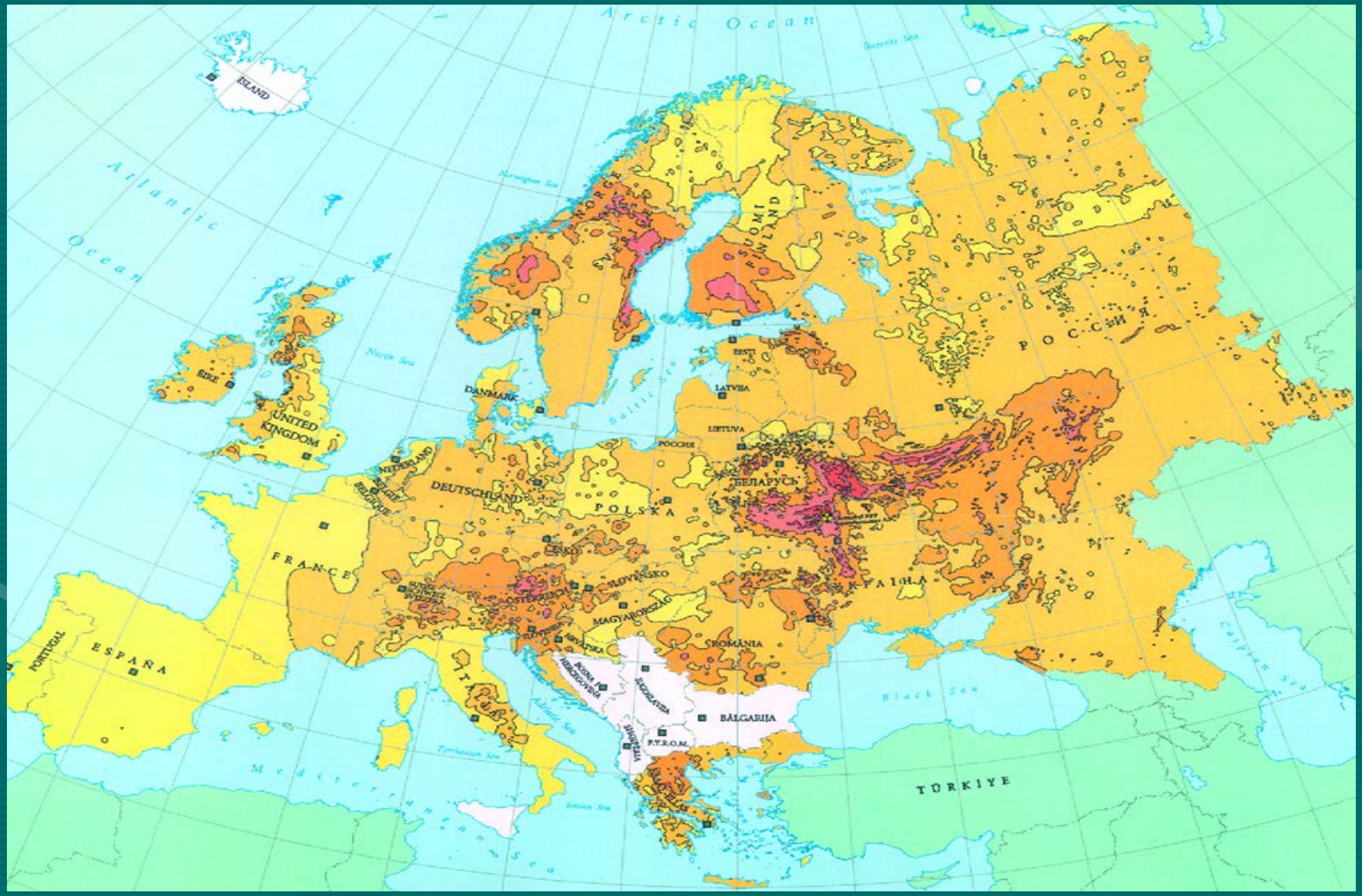
Planned evacuation from Pripyat city and voluntary relocation

Clean up and construction of the Shelter

Enormous scale of the early consequences of the accident

- Early health effects:
  - Two persons killed by explosion and thermal burns;
  - ARS in 134 emergency workers;
  - 28 of them died from ARS in 1986, 19 more died in 1987-2004 from various causes
- More than 500 ths recovery operation workers exposed
- About 14×10^{18} Bq radioactivity released; the most radiologically important radionuclides were ^{131}I and ^{137}Cs
- More than 200,000 sq. km of Europe 'contaminated' with ^{137}Cs, mostly in FSU countries
- 340 ths people evacuated or resettled in 1986 and later
- More than 6 mln. people live in 'contaminated' areas
- Economic costs of hundreds billions USD

Deposition of ^{137}Cs in Europe

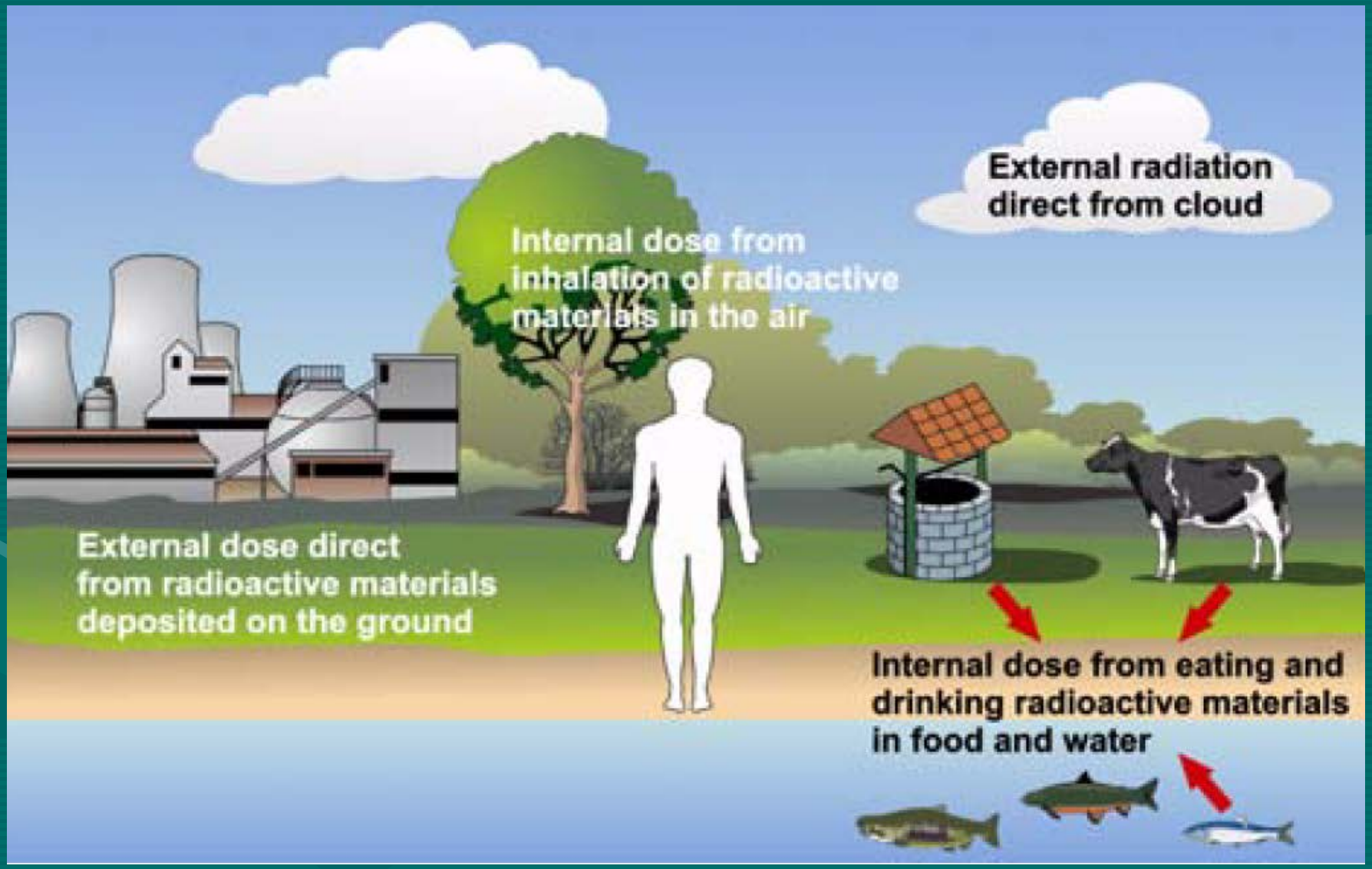


Communication with the public and neighboring countries

In line with the Soviet tradition of secrecy in all nuclear issues:

- Media reported about the accident in two days in very general terms;
- Environmental radiation levels and doses were kept classified for the public until 1989;
- Insufficient information released by the Soviet authorities complicated application of protective actions off-site;
- Abroad, first information received from measurements conducted on April, 27 at Swedish NPP;
- Later on, cooperation with IAEA established and comprehensive information provided in summer 1986.

Human exposure pathways

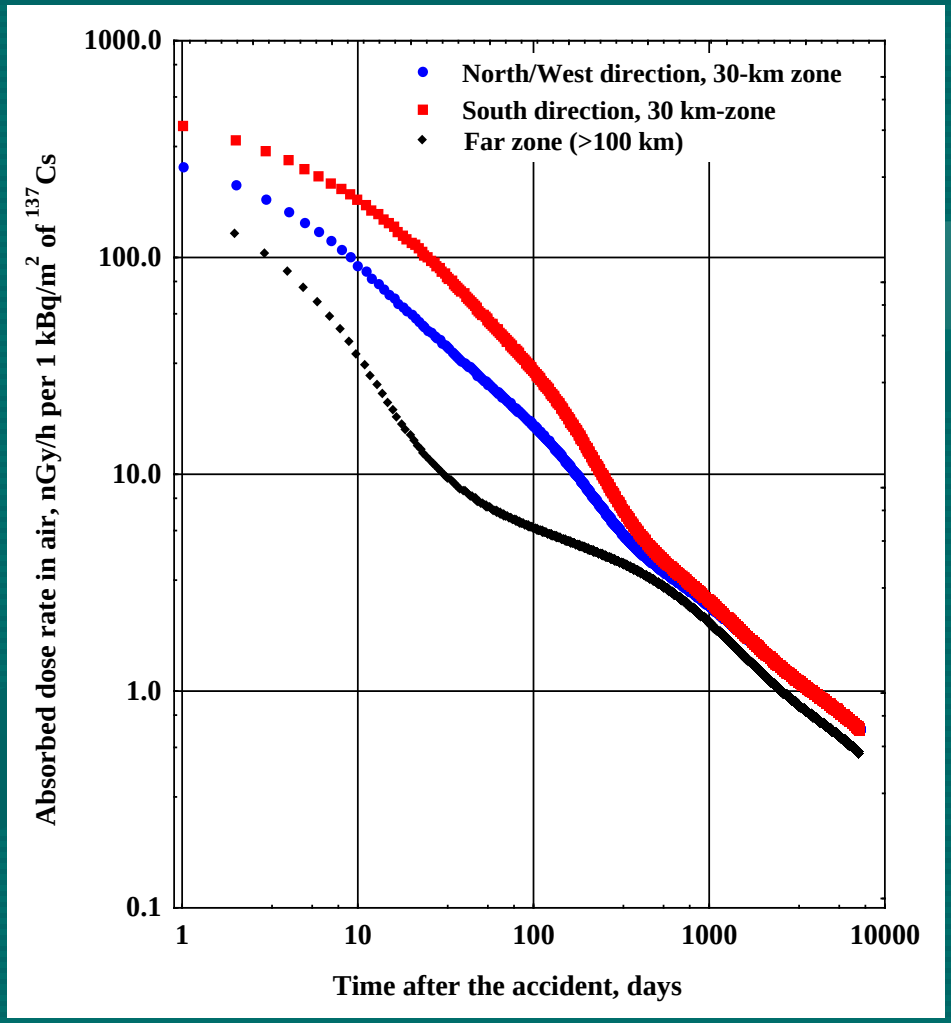


Major components of post-Chernobyl food management

- Food safety standards established in May 1986
- Food monitoring and inspection provided
- Agricultural countermeasures implemented
- Provision of clean food (mostly, milk and meat over the 1st year or longer)
- In total, reduced collective internal effective dose of B, R and U residents by a factor of about 1.5 (thyroid dose excluded)

Environmental radiation levels

- Radiation levels in the environment have reduced by a factor of several hundred since spring 1986 due to natural processes and countermeasures.
- The majority of the recovery operation workers and residents of the 'contaminated areas' in B, R and U received relatively minor radiation doses, which are comparable with natural background levels.



Current status

- Annual whole body doses of the public declined by some tens compared with 1986;
- Road maps for the return of the public to normal way of life without radiological restrictions are under discussion in B, R and U;
- There is ongoing discussion on future industrial use of land abandoned after the Chernobyl accident;
- The New Safe Confinement above the destroyed reactor is under construction. It will isolate Unit 4 from the environment for the next 100 years.

New Safe Confinement, Oct 2016

Chernobyl health effects research

- Early and late health effects of ARS survivors
- Environmental and human radiation measurements and dose reconstruction
- Registries of persons exposed to Chernobyl-caused radiation
- First increase of thyroid cancer incidence rate in Belarusian children in early 1990s
- Analytical studies of workers and general public
- Future perspectives

Early and late health effects of ARS survivors

- Treatment and simultaneous study of more than 200 workers, who received large radiation doses (134 of them contracted ARS), started immediately.
- Comprehensive study included all the body systems that could be affected by radiation with primary attention to hemopoietic system and local injuries.
- “Gold mine” for radiation medicine, numerous international publications.
- The study of long-term health effects is still ongoing in Kiev and Moscow.

Human radiation measurements

- 250 ths. workers from 1986-1990 (48% of all workers) with personal dose records;
- May-June 1986 – 350 ths. ^{131}I thyroid measurements of residents, primarily children. Used for mass thyroid dose reconstruction.
- Since June 1986, mass whole body counting (WBC) of Cs in residents; in total, about 150 thousand in 1986. More next years, continued until now, used for dose assessment.
- Since late 1986, selected TLD measurements of residential external dose; in total several thousand. Used for model validation.
- Human measurements actively used in health effect studies because of lower dose assessment uncertainty.

Dose reconstruction

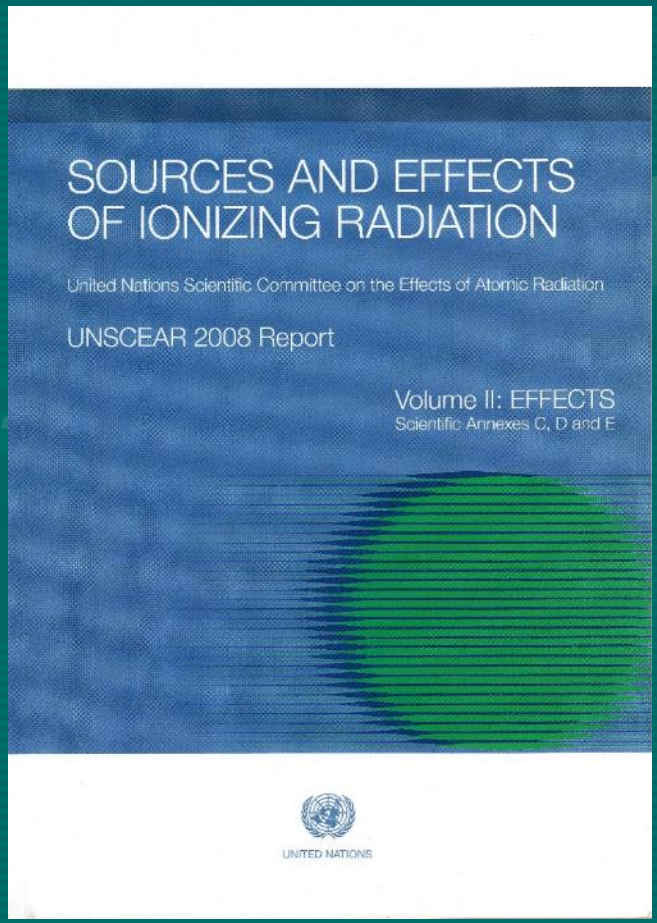
- Started soon after the accident and required substantial efforts of B, R and U experts supported by US and European experts.
- Focused on reconstruction of individual doses of persons involved in various health effect studies, i.e.
  - whole body doses and thyroid doses of both
  - workers and members of the public.
- Sophisticated methods based on environmental and human measurements linked by models elaborated.
- The most sensitive issue remains dose uncertainty assessment; some of this work is still on-going.

Registries of persons exposed to Chernobyl-caused radiation

- In June 1986, USSR Ministry of Health established All-Union Distributed Registry of persons exposed to radiation due to the Chernobyl accident.
- Since that time, both the Central registry (Obninsk, Russia) and similar registries in Belarus, Ukraine, Baltic countries, etc. collect data on health conditions and radiation doses of more than 600 thousand workers from 1986-1990.
- The registries also collect data on some million members of the general public residing in the affected areas.
- Those data are regularly analyzed in order to reveal radiogenic health effects, including oncological and cardiovascular diseases.

Late health effects under study

- Thyroid cancer
- Leukaemia
- Other solid cancers
- Non-cancer effects:
  - Cataracts
  - Cardiovascular and cerebrovascular diseases
  - Autoimmune thyroiditis
  - Malformations at birth
- Psychological and mental health problems



Analytical epi studies of the general public

- Started after the first increase of thyroid cancer incidence rate was detected in Belarusian children in early 1990s.
- Depending on study objectives, various case-control groups or large cohorts were established and studied.
- Some of the analytical thyroid studies are still on-going, e.g. Bel-Am and Ukr-Am cohorts of about 25,000 children with individual ^{131}I thyroid measurements.
- The Chernobyl thyroid tissue bank was established in UK and used in relevant biological studies.
- Case-control studies of leukaemia among those exposed *in utero* and as children were conducted in Ukraine.

Analytical worker studies

- Conducted in parallel in Russia, Ukraine and Baltic countries.
- The most informative have been studies of:
  - leukaemia and solid cancer, including thyroid cancer,
  - cardiovascular diseases,
  - cataract incidence.
- ARS cases and their long-term consequences have been carefully studied beyond analytical study program.

Current and future radiobiological studies

- Special attention is paid to identification of various biological markers of exposure, especially low-dose exposure, and of radiogenic health effects.
- Sometimes, outstanding findings are published
- Their practical value still has to be determined.

Conclusions - 1

- The Chernobyl accident had by far the largest radiological consequences from all the radionuclide releases to the environment.
- In 1986, the USSR authorities made enormous efforts for accident mitigation.
- Large scale protective actions started immediately. In some areas of Europe, primarily in Belarus, Russia and Ukraine, remedial actions are still in progress.

Conclusions - 2

- On the accident day, more than 500 emergency workers received large radiation doses that resulted in 134 ARS cases.
- In 1986-1990, more than 500 thousand recovery operation workers were exposed to elevated radiation doses.
- More than 5 million people live in areas of Belarus, Russia and Ukraine with elevated radiation levels.
- The most radiologically significant exposure pathway for the public was ingestion of radioiodine with food in April-May 1986. That resulted in several thousand thyroid cancer cases in children (as of 1986).
- Further long-term external and internal exposure of the public to radiation of Cs radionuclides did not result in discernible health effects.

Conclusions - 3

- The Chernobyl accident opened big opportunity for radiological research.
- Over the last 30 years,
  - Some new low dose health effects revealed (e.g., thyroid cancer from radioiodine, cataract),
  - Knowledge of radiation-induced health effects substantially advanced from worker and public studies,
  - Infrastructure for further epidemiological and radiobiological studies created.
- Ample research opportunities are still open, many promising studies go on.

Thank you for your attention!