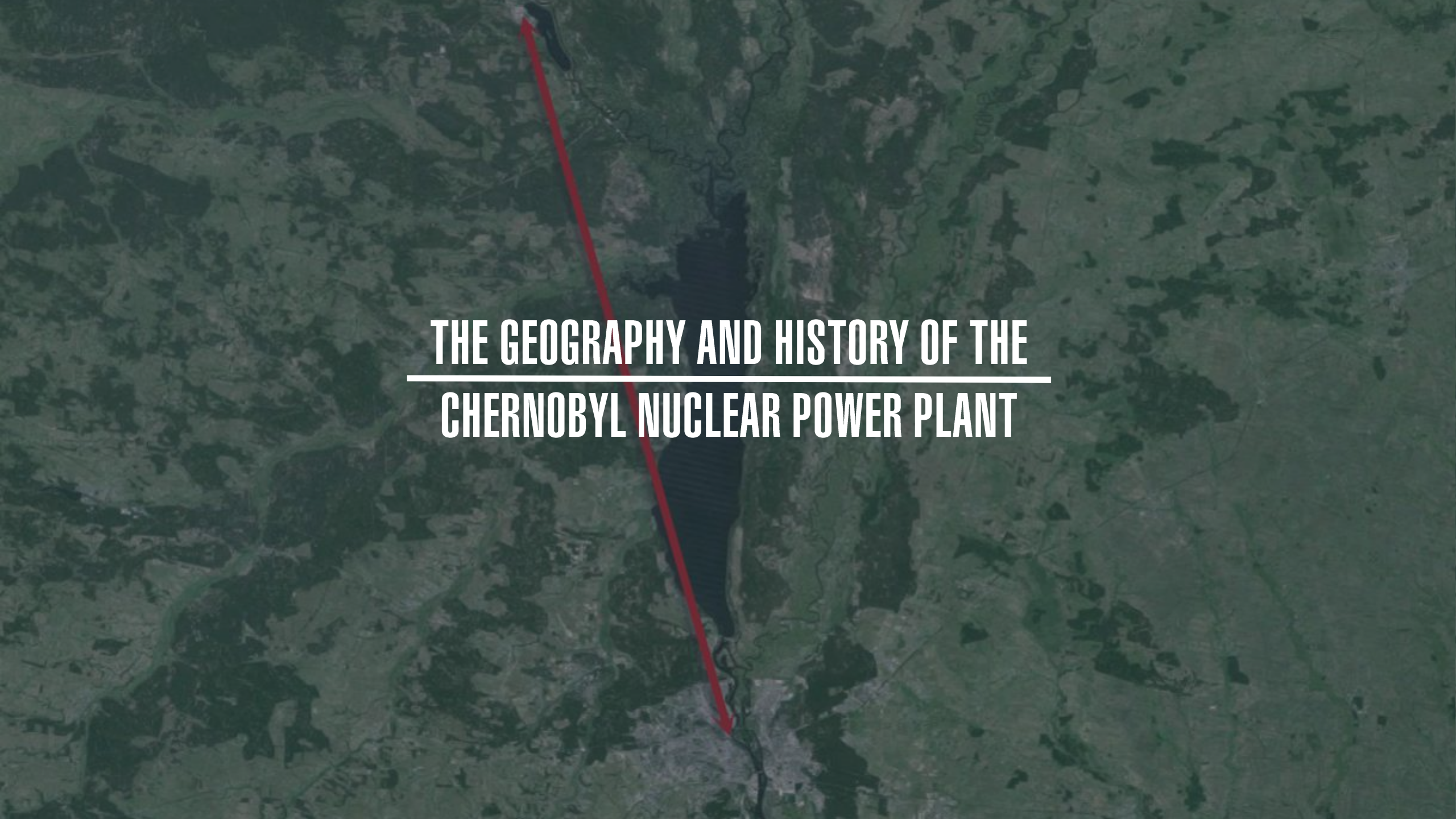


CHERNOBYL

The Past,
The Present,
The Future



An aerial satellite-style map of Ukraine is shown in a dark, muted green color. A prominent red double-headed arrow is oriented vertically, pointing from the top of the map to the bottom. A white horizontal line is drawn across the center of the map, passing through the arrow. The text of the title is centered on this line.

**THE GEOGRAPHY AND HISTORY OF THE
CHERNOBYL NUCLEAR POWER PLANT**



Pripyat River

Slavutych-Semikhody train

Прип'ять
Pripyat

UKRAINE

BELARUS

UKRAINE

ChNPP

ChNPP cooling reservoir

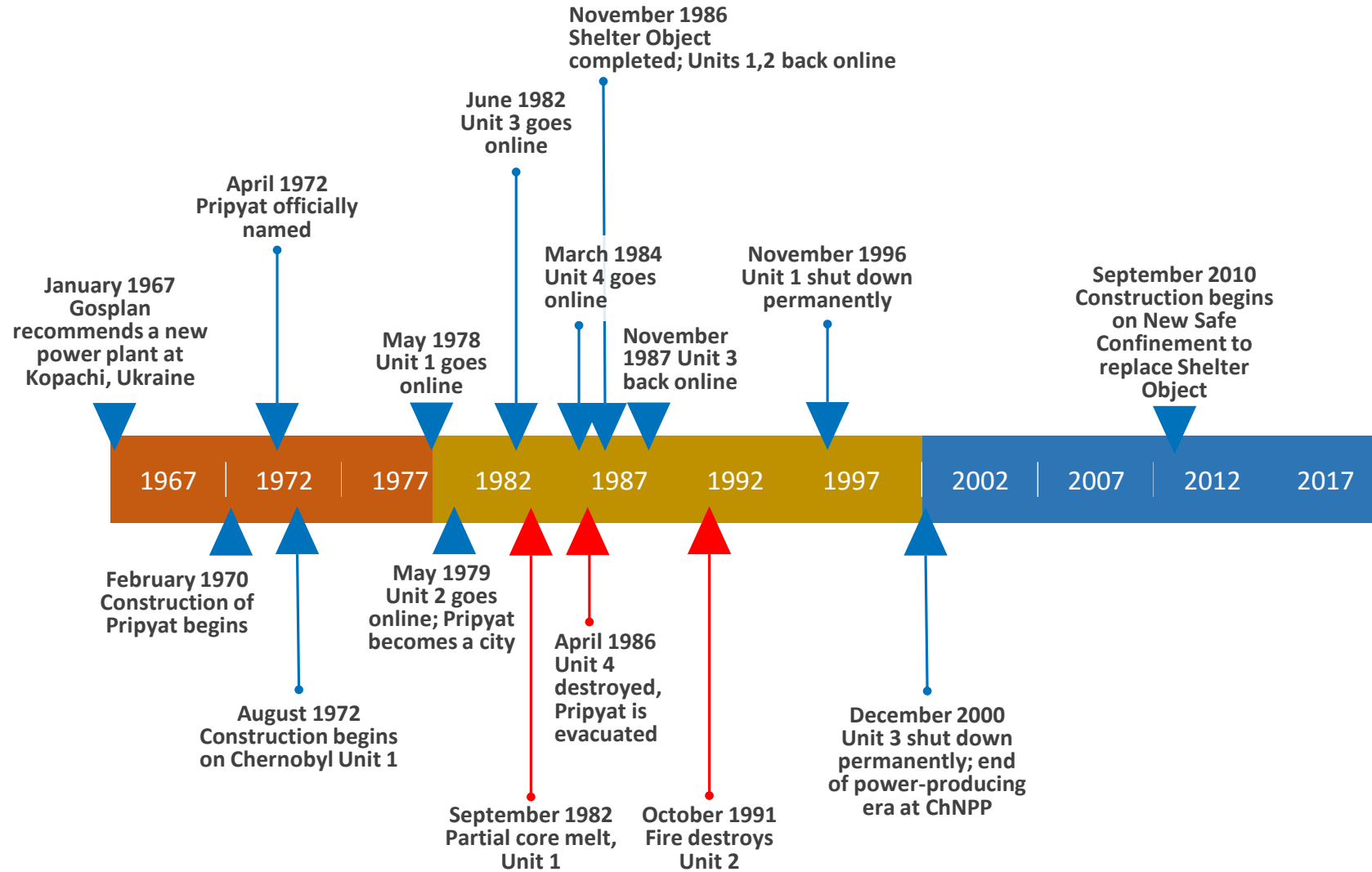
The "island":
Units 5-6
construction site

Chornobyl
Чорнобыль

Kiev,
180 km

Ворovyкy
Борovyкы

EVENTS AT CHERNOBYL







4

3

2

1



The image shows the interior of a nuclear reactor core. A large, complex structure of metal and pipes is visible in the center, surrounded by a grid of concrete or metal blocks. On the right side, there is a prominent yellow vertical structure with red bands. In the foreground, several workers in white protective suits are visible, indicating a controlled environment. The overall scene is dimly lit, with a blueish tint.

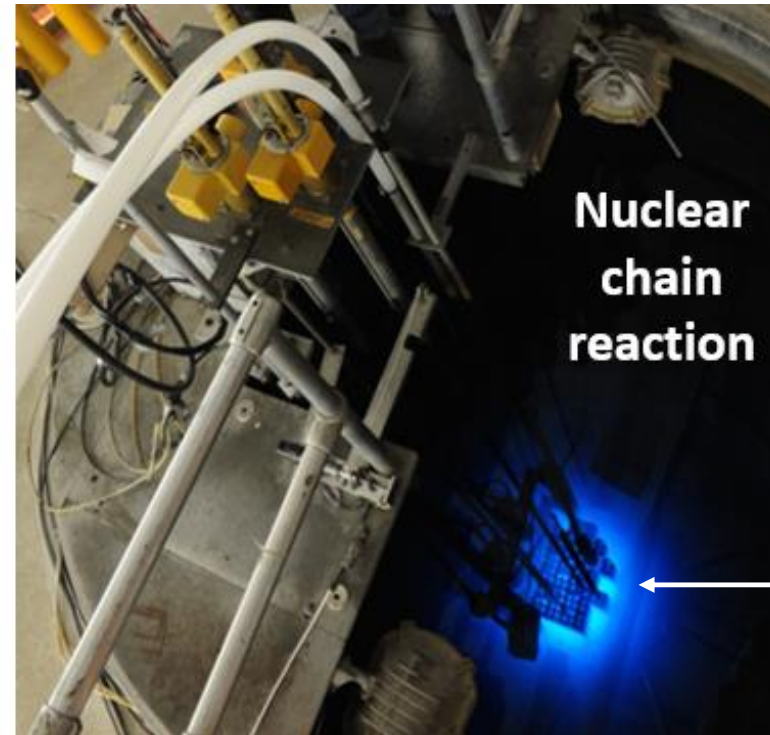
NUCLEAR REACTOR DESIGN AND REACTOR PHYSICS

CHAIN REACTING SYSTEMS



**Chemical
chain
reaction**

Fuel



**Nuclear
chain
reaction**

Fuel

Chain-reacting systems are familiar (e.g., fire). Feedback, stability, and control concepts in nuclear reactors may be compared to the behaviors of fires.

CHAIN REACTING SYSTEMS

Fuel is combustible material that reacts with air when exposed to heat, producing more heat, which can cause combustion in additional fuel.

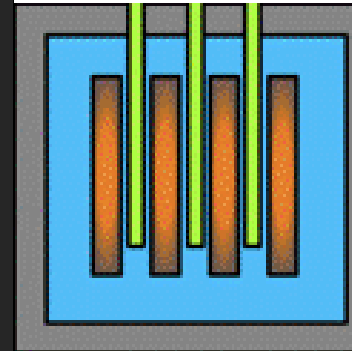
Fuel is atomic nuclei that explode when they absorb slow-moving neutrons, producing more neutrons (generally fast-moving ones). The moderator slows down fast neutrons so they will cause fission in additional fuel.



Reactivity depends on heat transfer efficiency (separation of fuel pieces), heat leakage (shape and size of the system), and availability of fuel and air.



Reactivity depends on neutron transport, including moderation (separation of fuel pieces), neutron leakage (shape and size of the system), and availability of fuel.



CONTROLLING FIRES

1. Increase or reduce the efficiency of heat transfer between fuel
2. Decrease efficiency by putting water, or damp fuel, in the fire (water evaporation removes heat).
3. Increase efficiency by moving fuel pieces closer together, or by burning dryer fuel.

CONTROLLING REACTORS

1. Increase or reduce the efficiency of neutron transfer between fuel nuclei
2. Decrease efficiency by putting neutron-absorbing material (typically called control rods) between fuel elements.
3. Increase efficiency by withdrawing the control rods.

FIRES AND NUCLEAR REACTORS

FEEDBACK:

Feedback refers to a system influencing its own behavior.

POSITIVE FEEDBACK:

A perturbation to a parameter of the system causes a response that moves that parameter in the same direction as the stimulus. Can promote instability.

NEGATIVE FEEDBACK:

A perturbation causes a response that moves the parameter in the opposite direction of the stimulus. Favors stability.

POISONING:

Fires and nuclear reactors both generate byproducts that interfere with—or “poison”—the chain reaction.



EVOLUTION OF THE ACCIDENT

EVOLUTION OF THE ACCIDENT

Time	Event / Action	Result
~12:00 AM April 26 1986	Failure to maintain computerized automatic control of reactor power at intended power level.	Reactor almost shuts down. Xe-135 poison builds up, suppressing ability to resume intended power.
~1:00 AM	Operator attempts to maintain power. He must remove almost all the control rods.	Only neutron absorber left in core is boiling water. Positive power reactivity feedback scenario. Power begins rising.
1:23 AM	Test concludes, operator presses button to insert all control rods. (Unknown whether he does this because of power surge, or because he was attempting a normal shutdown.)	Control rod tips push water out of the core, adding reactivity because the tips are made of a poor absorber. Reactor power rises uncontrollably; core damage impedes further control rod entry. ***EXPLOSION***

CHAIN REACTING SYSTEMS



The operator withdrew most **control rods** to counteract **poisoning**, leading to **positive power reactivity feedback** as water boiled in the core. When the operator attempted to replace the control rods, their **tips accelerated the power surge** and control was lost.

CONTRIBUTING FACTORS

OPERATOR

Operator Fault:
ChNPP staff performed contrary to regulation and technical instruction from the designer, contributing to the accident and its consequences. Six ChNPP staff convicted of misconduct in the Chernobyl Trial (1987), but the trend since has been exculpatory.

DESIGN

Flawed Design:
RBMK had dangerous characteristics, did not meet official safety mandates; some views suggest catastrophe “built in”. Upgrades addressed reactor issues most significant to accident.

SAFETY

Deficient “Safety Culture”:
Phrase coined by INSAG encompasses faults specific to Chernobyl and the wider system of nuclear power regulation and management in USSR; the Soviet industry, by its priorities, ideology, and organization, was accident-prone.

RISK

Residual Risk:
The constellation of technical / human circumstances leading to accident was preemptively unknown and practically unknowable; nuclear power is “inherently dangerous” even when handled competently; from an alternative viewpoint, “Science requires victims.”

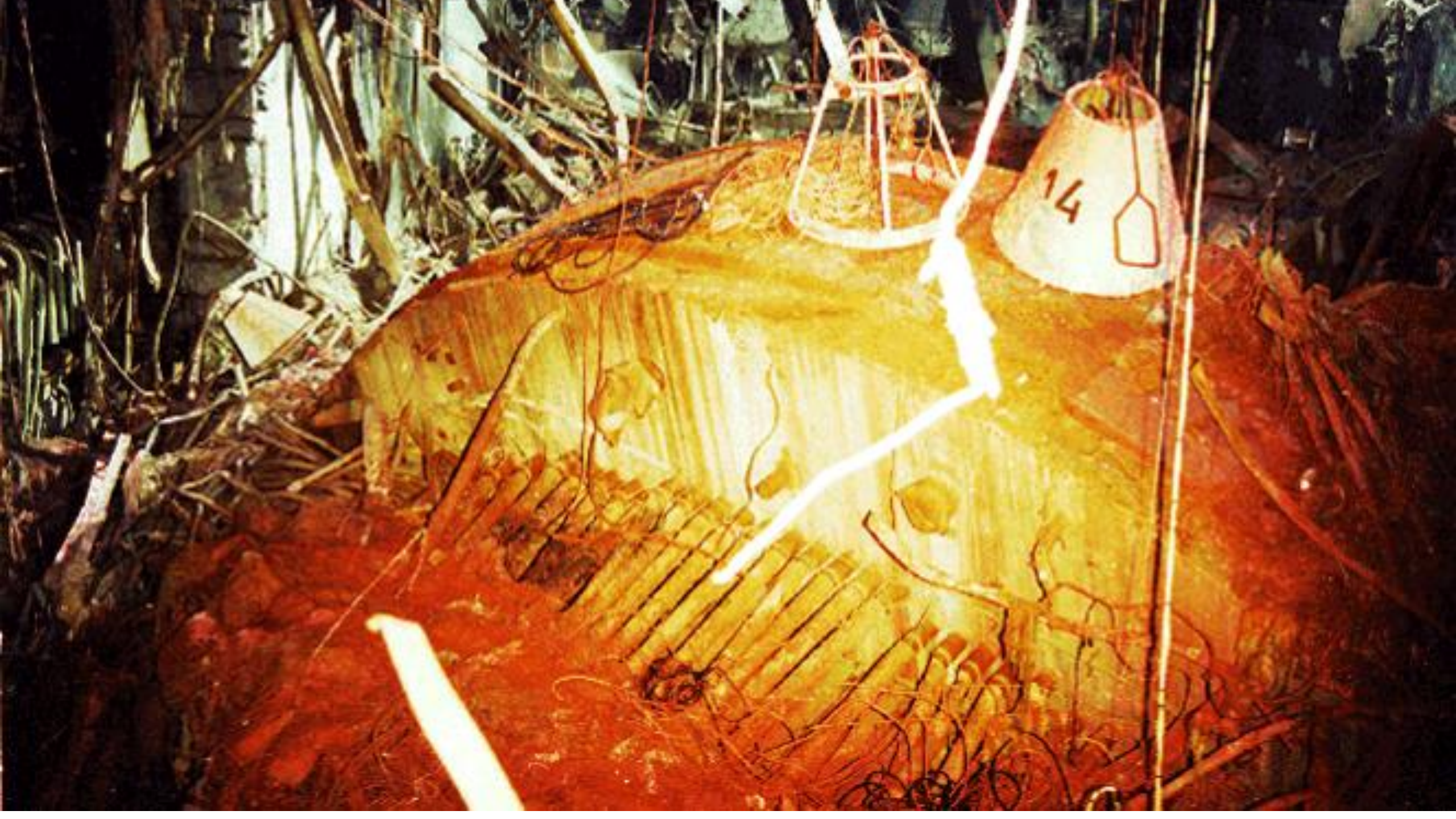


ASSESSING THE DAMAGE

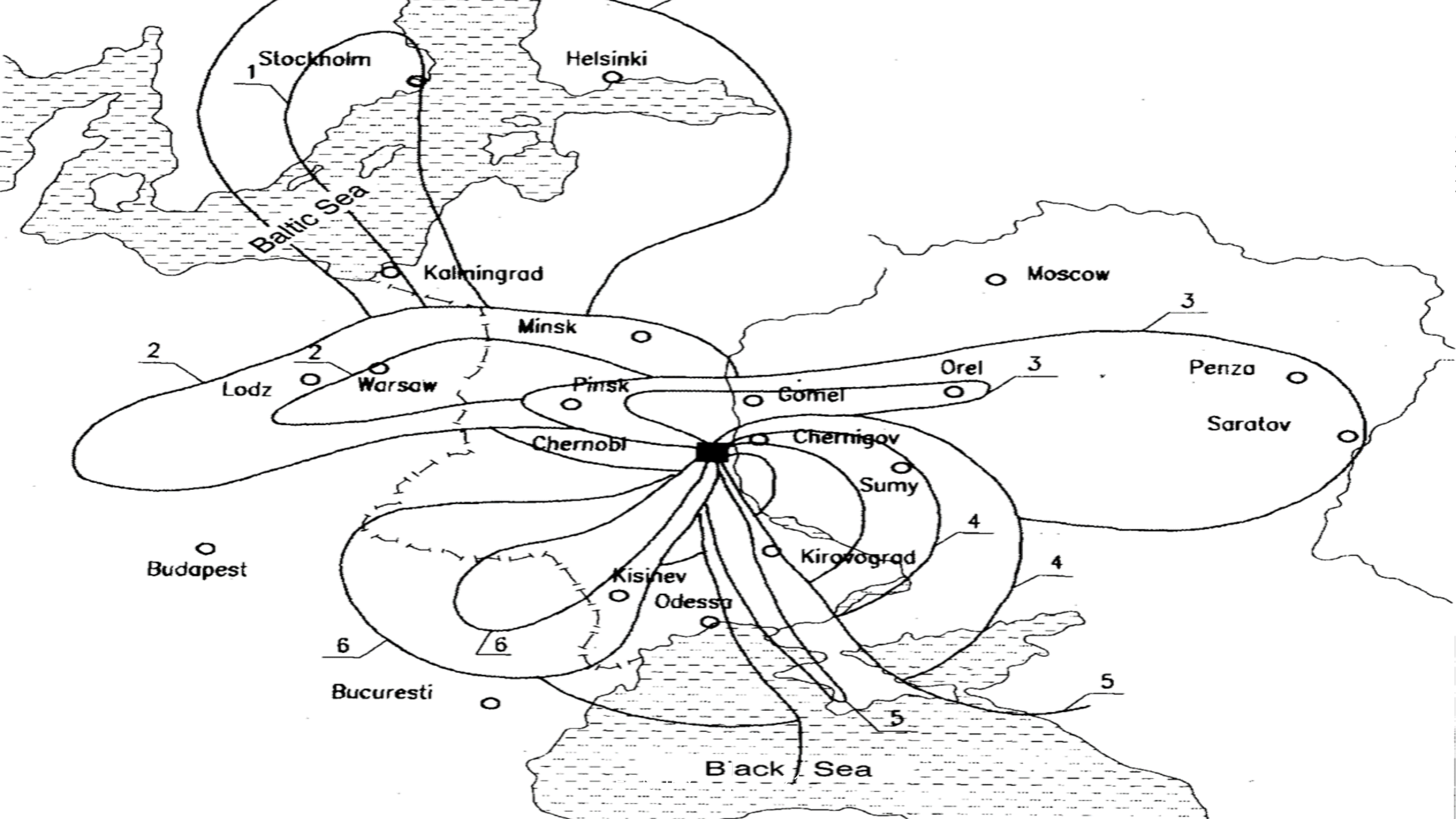












An aerial photograph of a large-scale construction site, heavily overlaid with a semi-transparent reddish-orange color. The image shows a complex network of concrete structures, including a prominent elevated walkway or bridge structure on the left side. The ground is a dense, chaotic arrangement of rebar, concrete forms, and other construction materials. The overall scene is one of intense industrial activity and structural development.

CONSTRUCTION OF THE SARCOPHAGUS

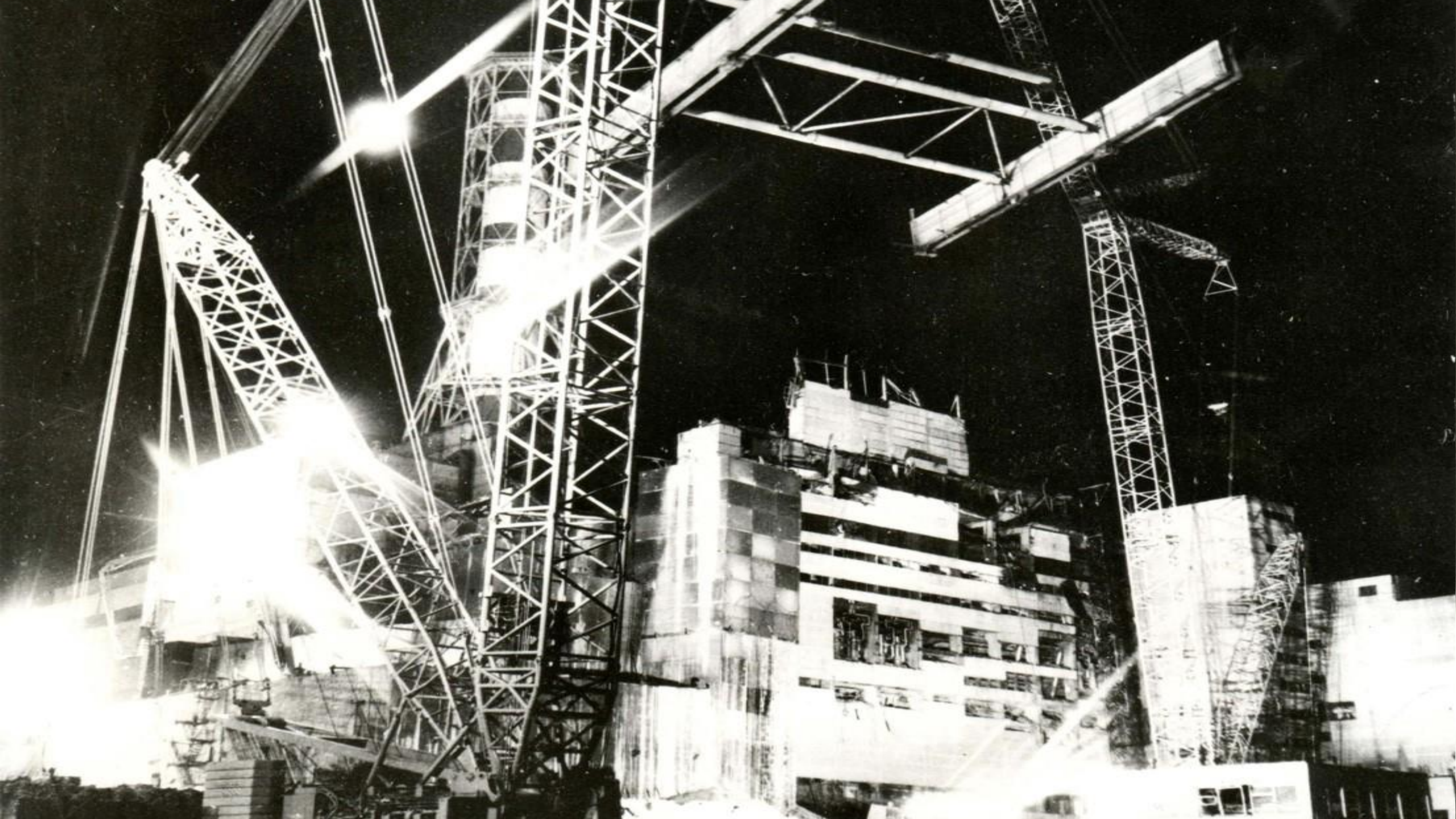




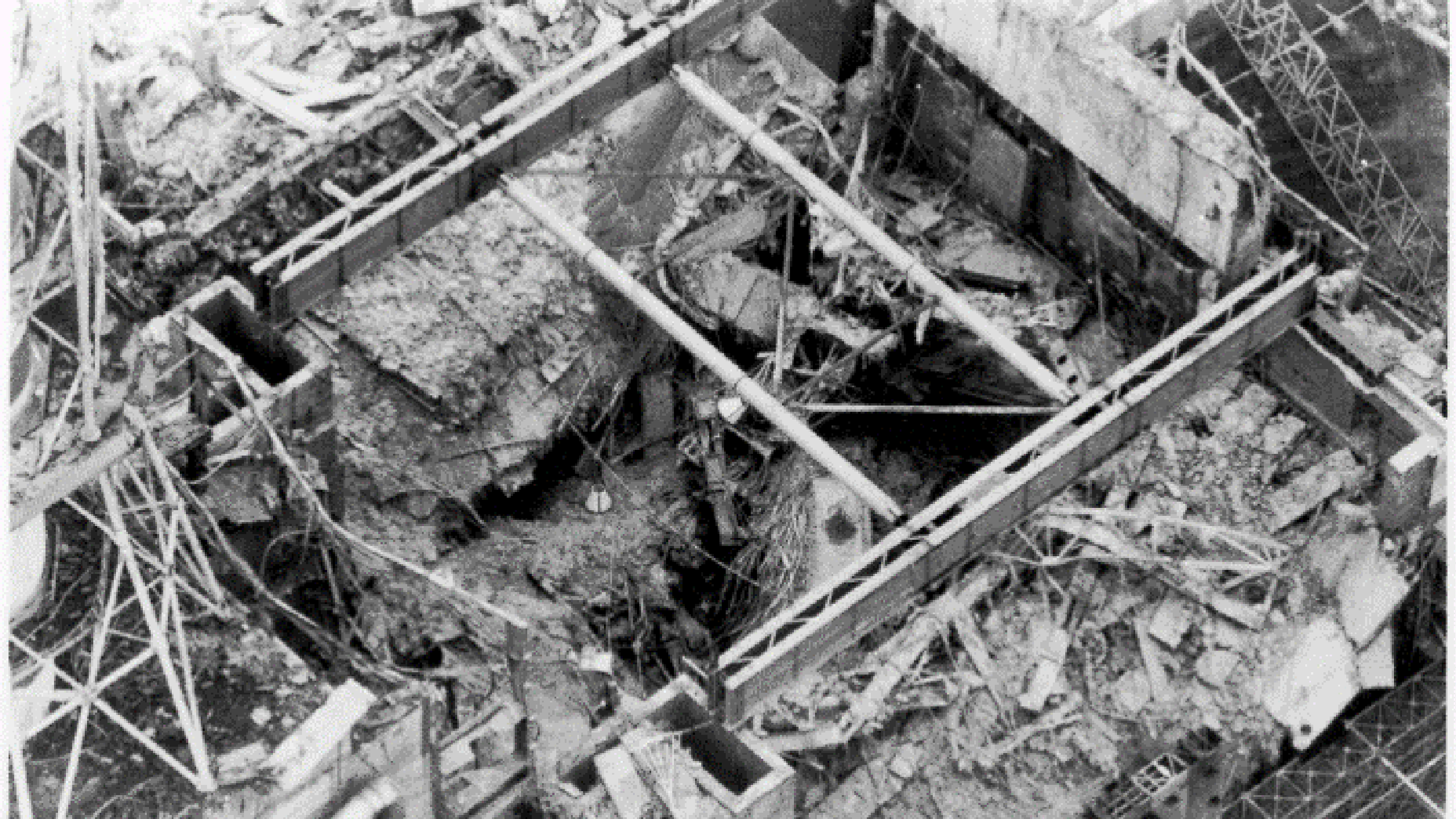




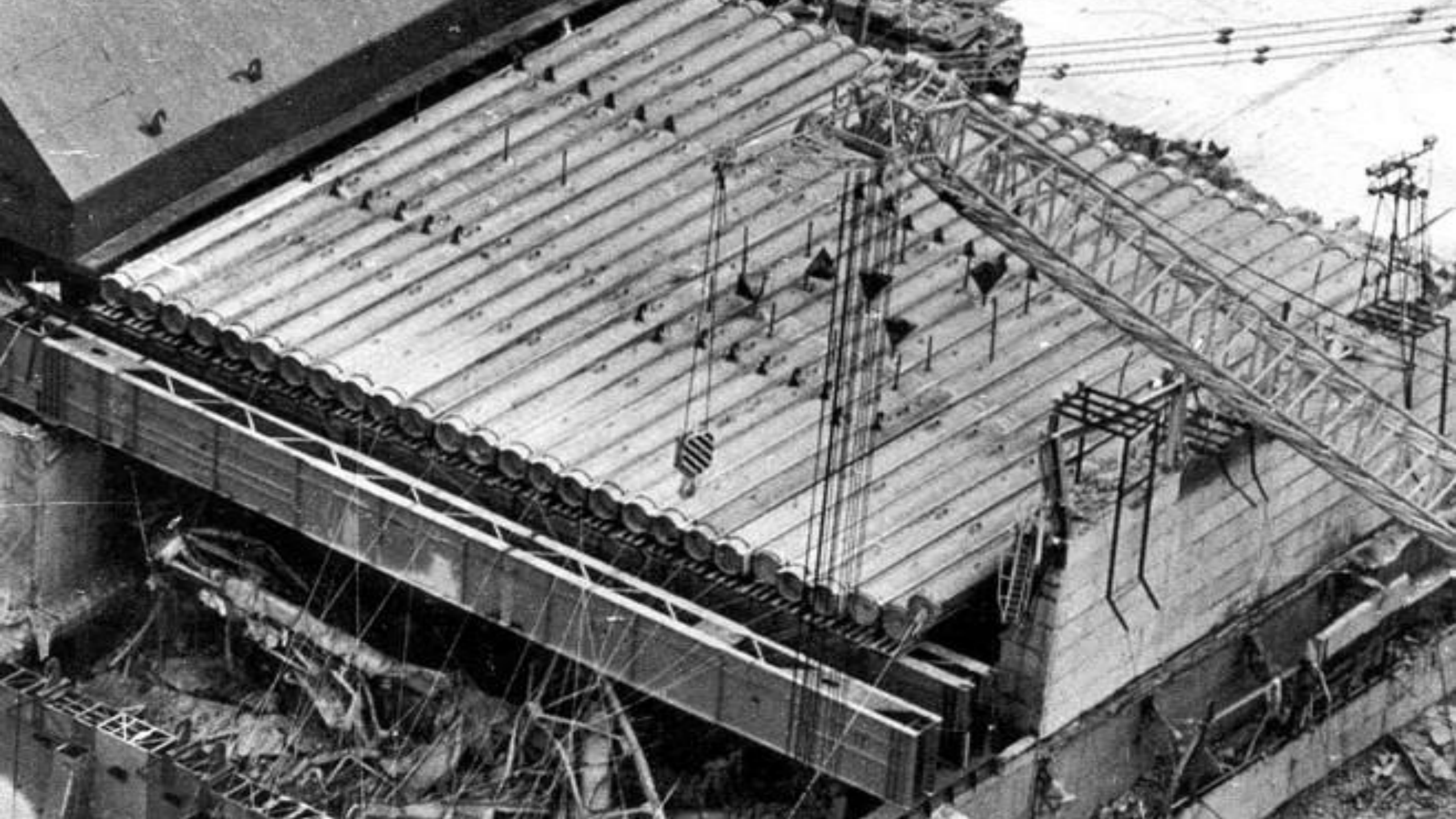














ЗАДАНИЕ ПРАВИТЕЛЬСТВА ВЫПОЛНИМ!







п. 914-2

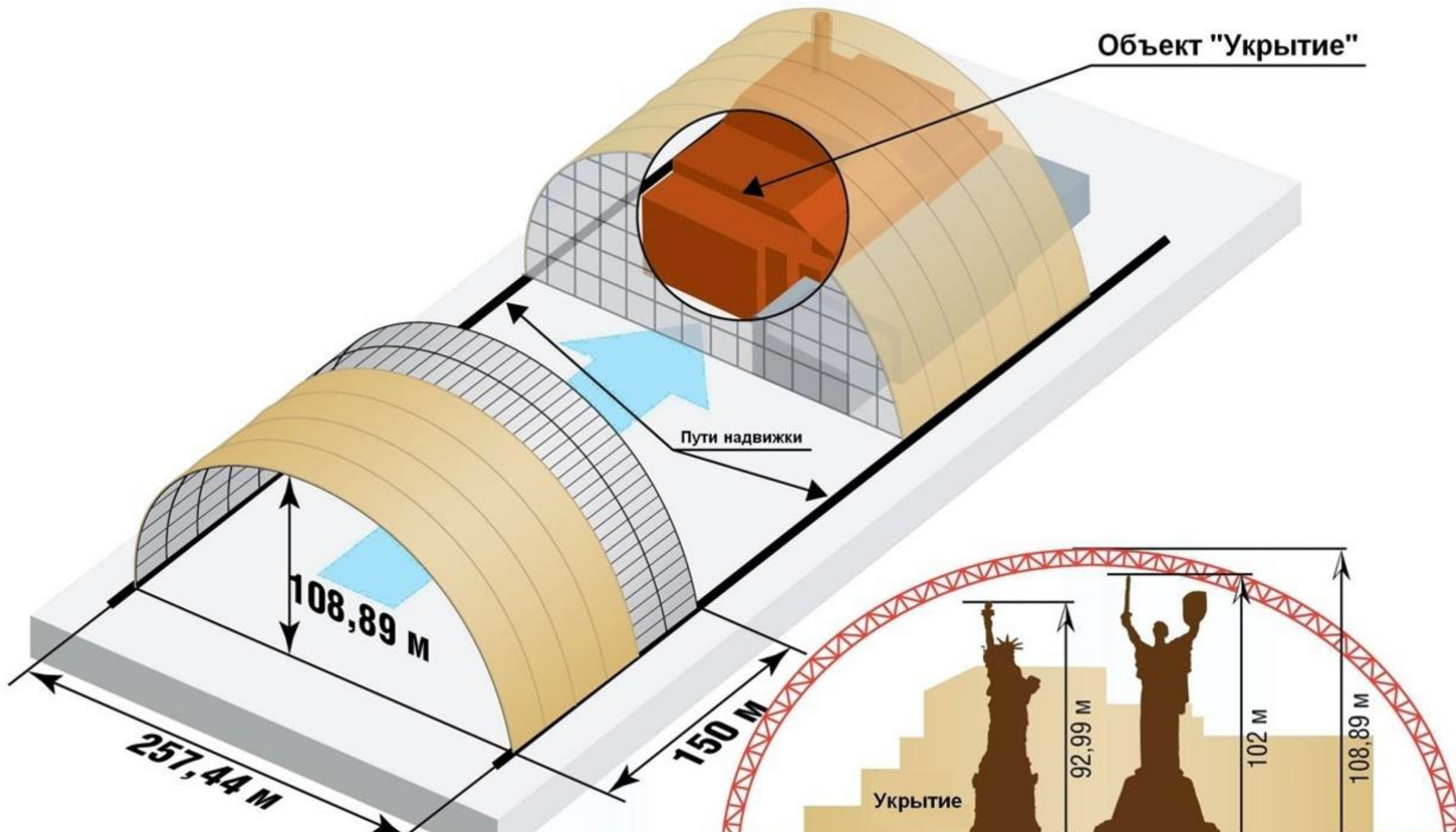


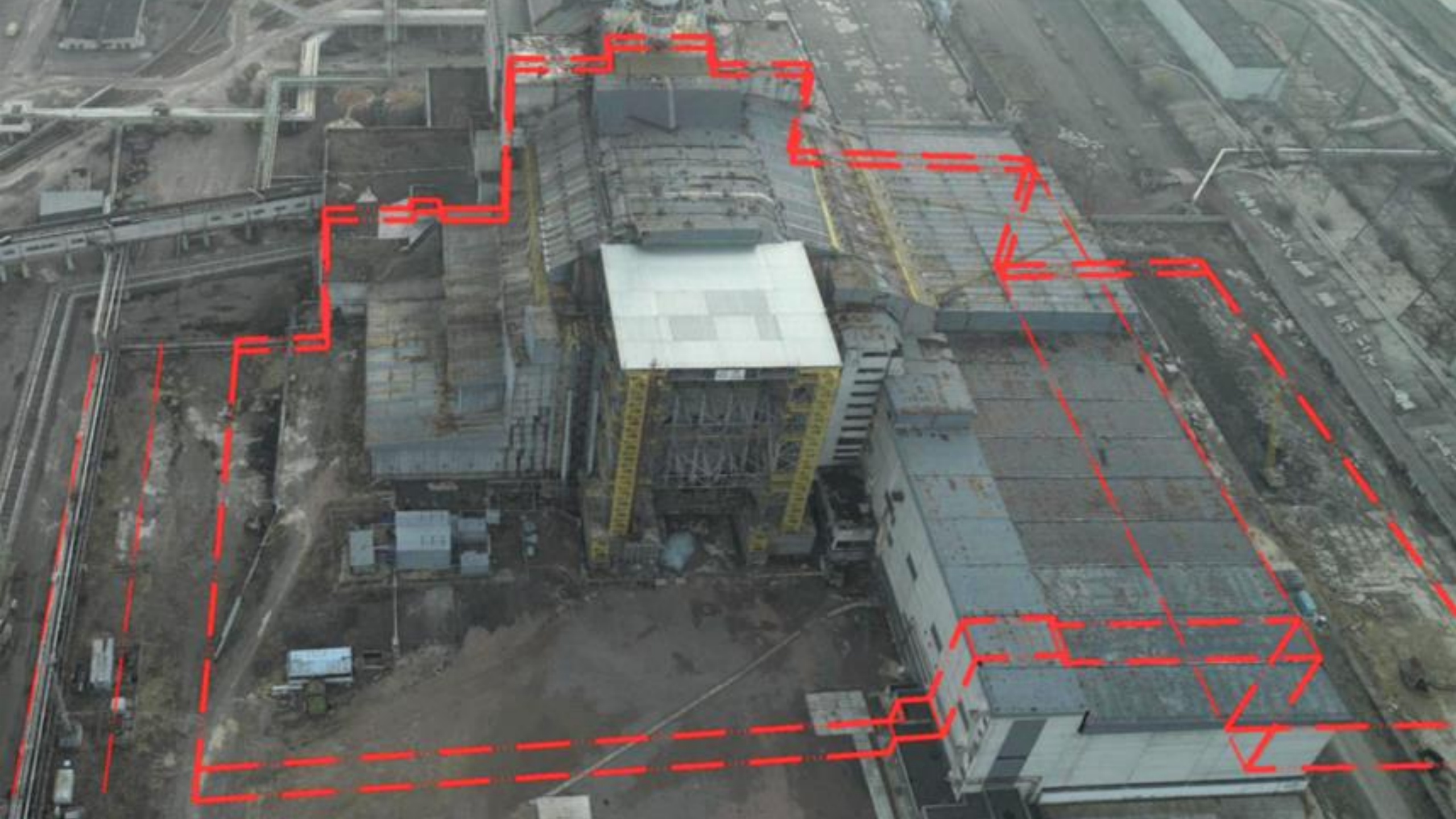


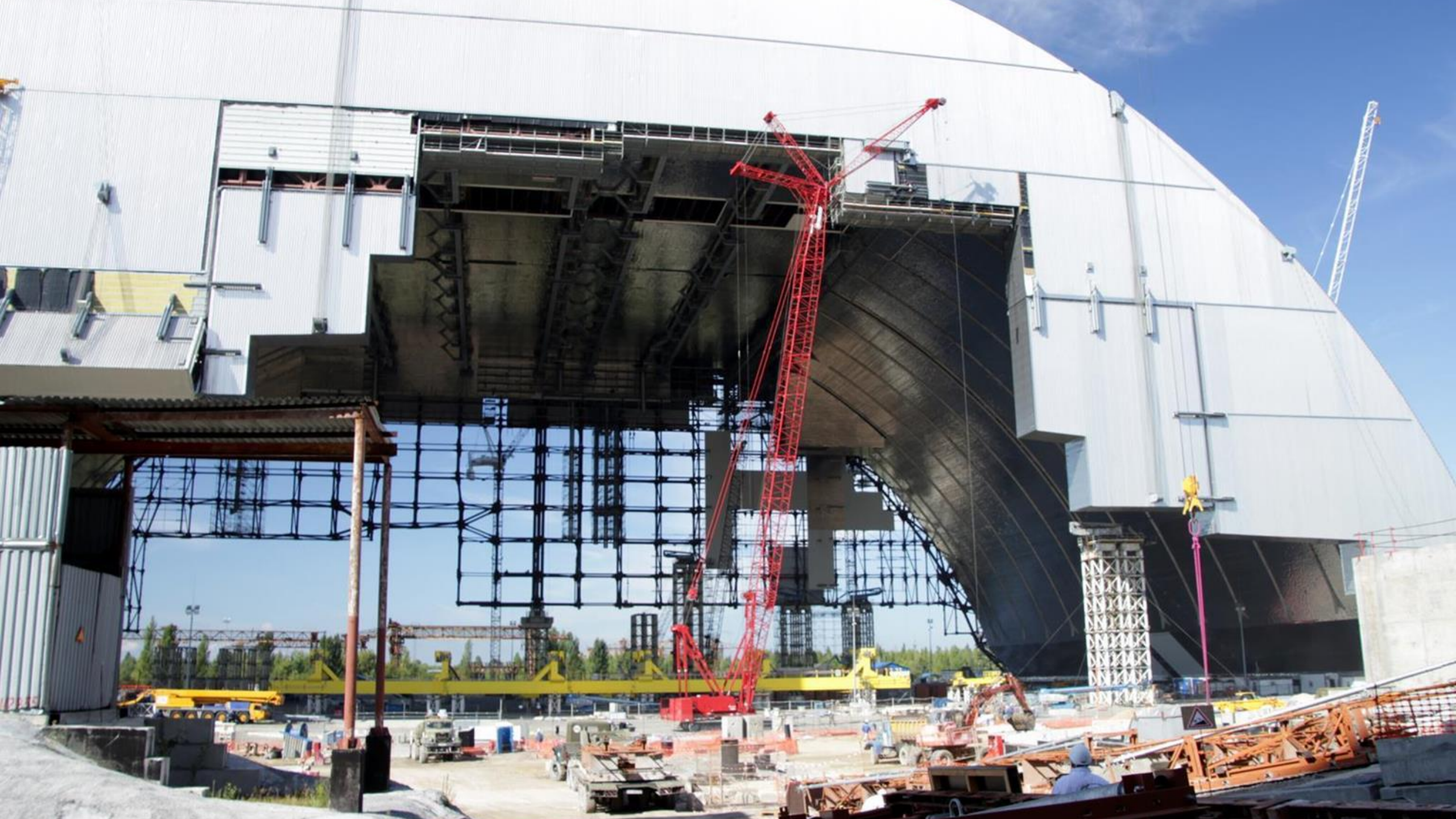
A large, dome-shaped industrial structure, possibly a containment vessel, is under construction. The structure is covered in a metallic, corrugated material. It is surrounded by extensive scaffolding and construction equipment, including a tall crane on the left and a smaller crane on the right. The scene is set outdoors on a dirt or gravel surface. The sky is a clear, light blue. The overall image has a warm, orange-tinted color palette.

NEW CONFINEMENT STRUCTURE

Объект "Укрытие"











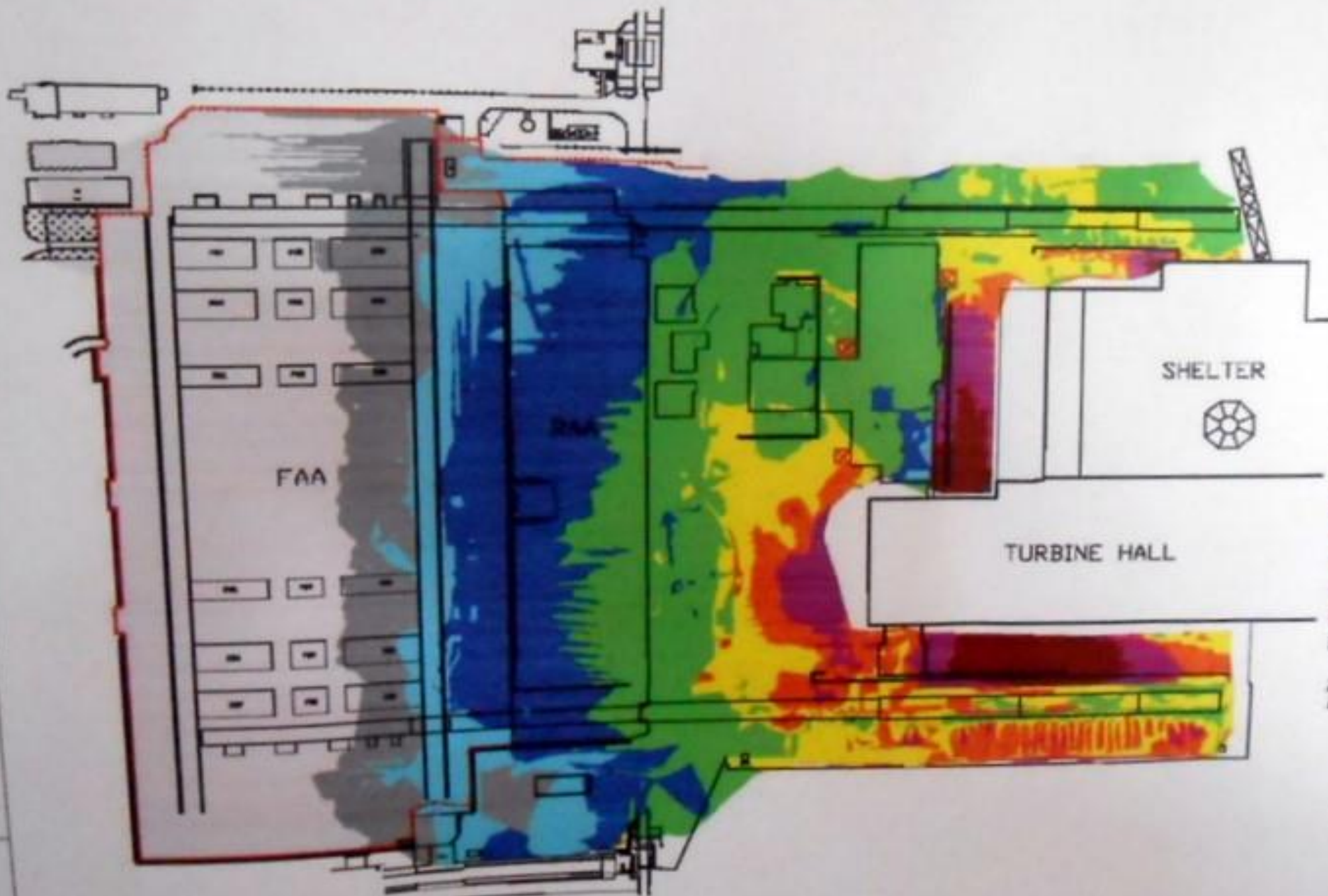


RADIOLOGICAL CONDITIONS AT CHERNOBYL



CARTOGRAM on 14-05-2015

Chernobyl New Safe Confinement - Contract N° SIP08-1-001
Cartograms of the Radiation Situation - ADR - FAA, RAA-SCA, IZ & LZ
Картограмма радиационной обстановки в ЗСД, ЗСД-ОУД,
индустриальной и локальной зоны
SIP-N-RP-22-A7020-RPT-067-B

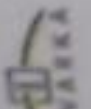


Performed with GPS &
Berthold LB 126
Number 6066
Valid until 17/06/2015

МАД / ADR
(γ): $\mu\text{R}/\text{ч}$ / $\mu\text{Sv}/\text{h}$

White	< 2.5
Light Grey	2.5 - 5
Light Blue	5 - 7.5
Dark Blue	7.5 - 15
Green	15 - 30
Yellow	30 - 45
Orange	45 - 60
Red	60 - 100
Dark Red	100 - 300
Black	>300

Dose rate measured at
1m above the ground





ЗАХОДИ
ІНТЕГРАЦІЯ ПЛАН

ПРОГРАМА
ІНТЕГРАЦІЯ ПЛАН

ПЛАН ЗДІЙСНЕННЯ ЗАХОДІВ НА ОБ'ЄКТІ "УКРИТТЯ" (SIP) НОВИЙ БЕЗПЕЧНИЙ КОНФАЙНМЕНТ (НБК) ОБ'ЄКТА "УКРИТТЯ"

ГОЛОВНА МЕТА НБК:
Забезпечити надійний захист від радіації та біологічних агресивних факторів на об'єкті "Укриття".

КОМПЛЕКС НБК: основна споруда, технологічний комплекс, допоміжні споруди.

Використання функцій:

... розроблений комплекс, який забезпечує надійний захист від радіації та біологічних агресивних факторів на об'єкті "Укриття".

... розроблений комплекс, який забезпечує надійний захист від радіації та біологічних агресивних факторів на об'єкті "Укриття".



Unit 4 Reactor Building

Vent. Building

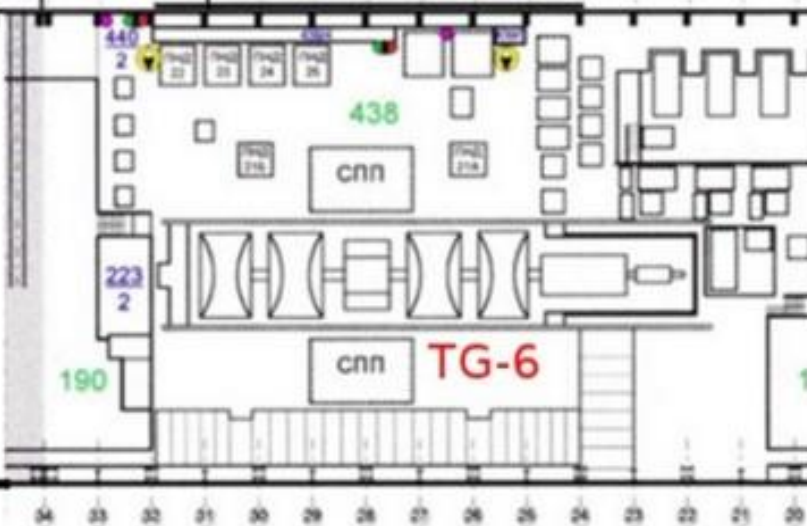
Unit 3 Reactor Building



Unit 4 Control Rm.

Unit 3 Control Rm.

Entombed part of turbine hall: TG-8 and TG-7







EOS DIGITAL

Canon

SCROLLZ

MT CBO-1



Model 26

LUDLUM MEASUREMENTS INC

55.0
kcpm

SN: PF003242

OK

M

M



A3

MIG-4131

INTEGRATOR A



MIP 2411
2300 8 2000
2000 10 2000

MIP 2411
2300 8 2000
2000 10 2000

MIP 2411
2300 8 2000
2000 10 2000

15



51



REDUCING WORKER EXPOSURES





HILTI

1333

















ONLY

4

ПРОХОД
ЗАКРЫТ

A landscape photograph showing a body of water, possibly a reservoir or a large pond, with a rocky and sandy shoreline. The sky is filled with large, white, fluffy clouds. In the foreground, a large, dark, cylindrical pipe runs horizontally across the frame. The overall scene suggests an industrial or environmental setting.

CONTAMINATION IN THE ENVIRONMENT

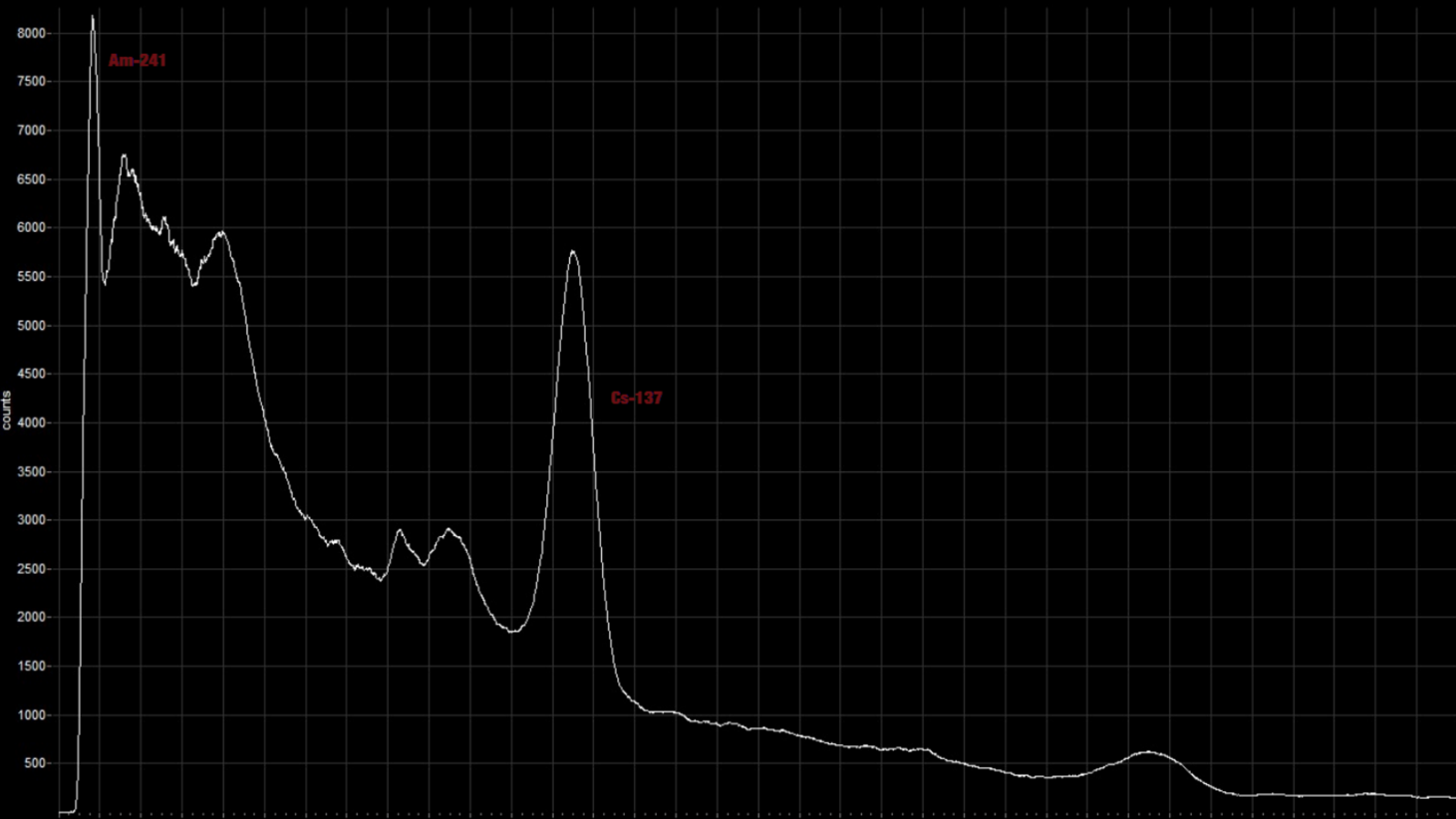






Isotope	Activity
Am-241	3,782 pCi/g
Ba-133	42 pCi/g
Cs-137	78,274 pCi/g
Eu-154	48 pCi/g
Gd-153	21 pCi/g
Ra-226	384 pCi/g





An aerial photograph of the Chernobyl nuclear power plant site, showing the damaged reactor building, containment structures, and surrounding infrastructure. The image is overlaid with a semi-transparent teal color. The text "CHERNOBYL INTO THE FUTURE" is centered in white, bold, uppercase letters, with a white horizontal line underneath it.

CHERNOBYL INTO THE FUTURE















A photograph showing several workers in white protective suits and hard hats inside a facility. Some workers are standing, while others are sitting on benches. The scene is dimly lit, and the overall tone is blue. The text "THE WORKERS OF CHERNOBYL" is overlaid in white, bold, uppercase letters, centered horizontally and partially obscured by a white horizontal line.

THE WORKERS OF CHERNOBYL









RJR

EP9T - 673







BYO-2



27















NOVARKA

KRAZ

72













NOVARKA







Thank you for supporting the workers at the Chernobyl Nuclear Power Plant

Acknowledgements

I would like to thank the plant managers and administration at the Chernobyl Nuclear Power Plant for allowing access and providing materials.

Image Credits

All images were provided courtesy of:

Lucas W. Hixson

Carl Willis

Heidi Baumgartner

Dr. Sonja Schmid

The Chernobyl Nuclear Power Plant

