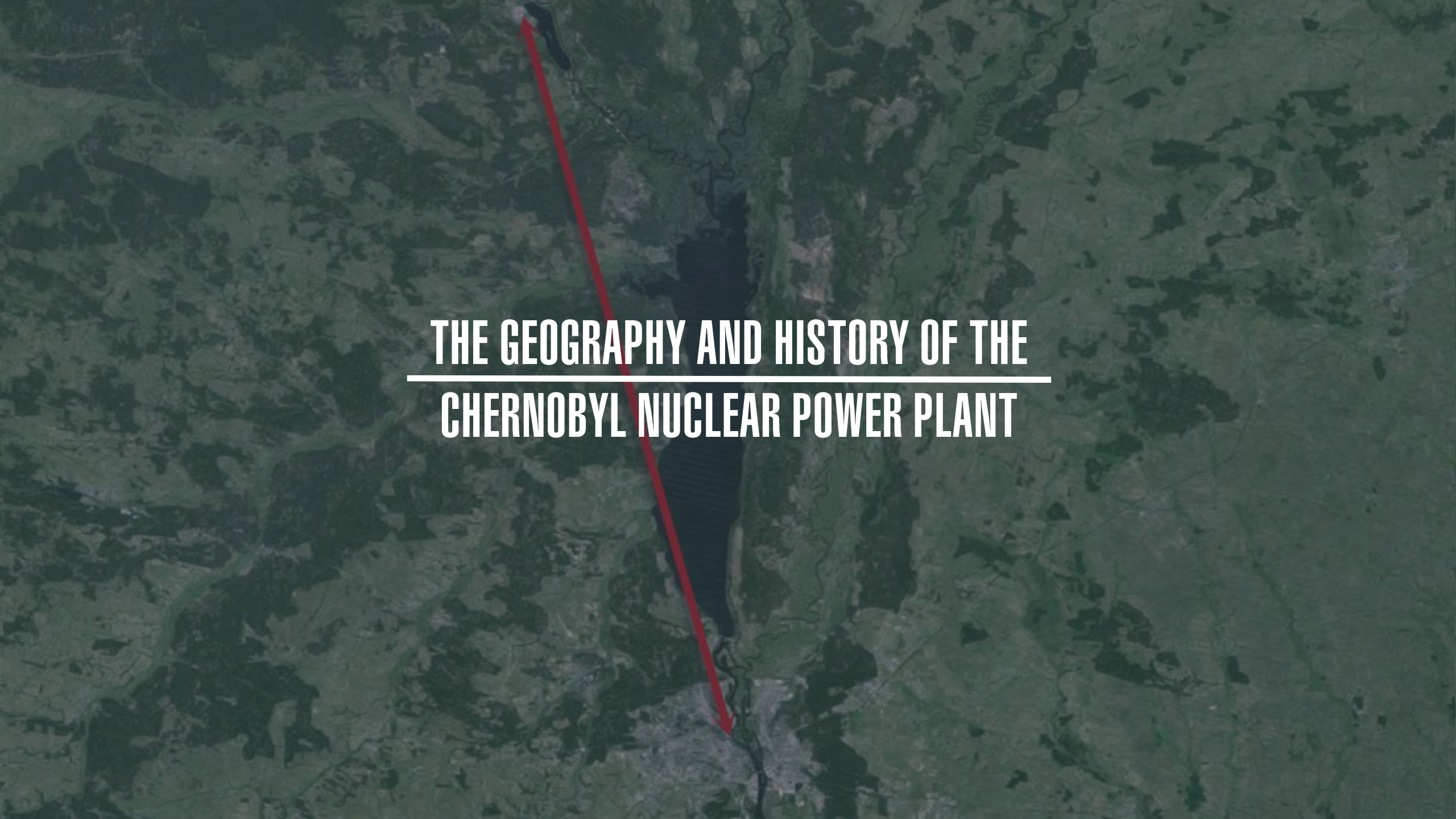
CHERNOBYL

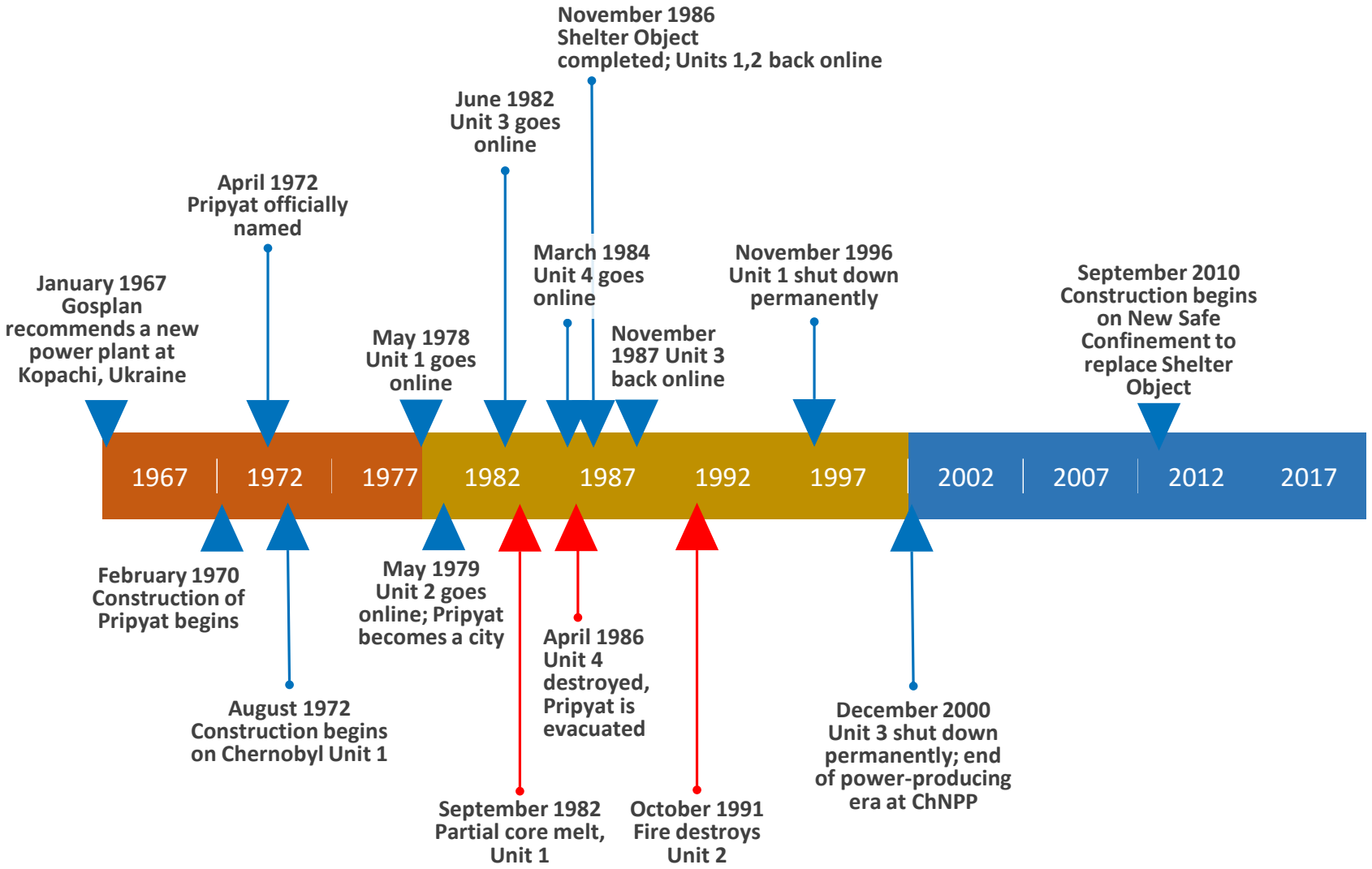
The Past,
The Present,
The Future



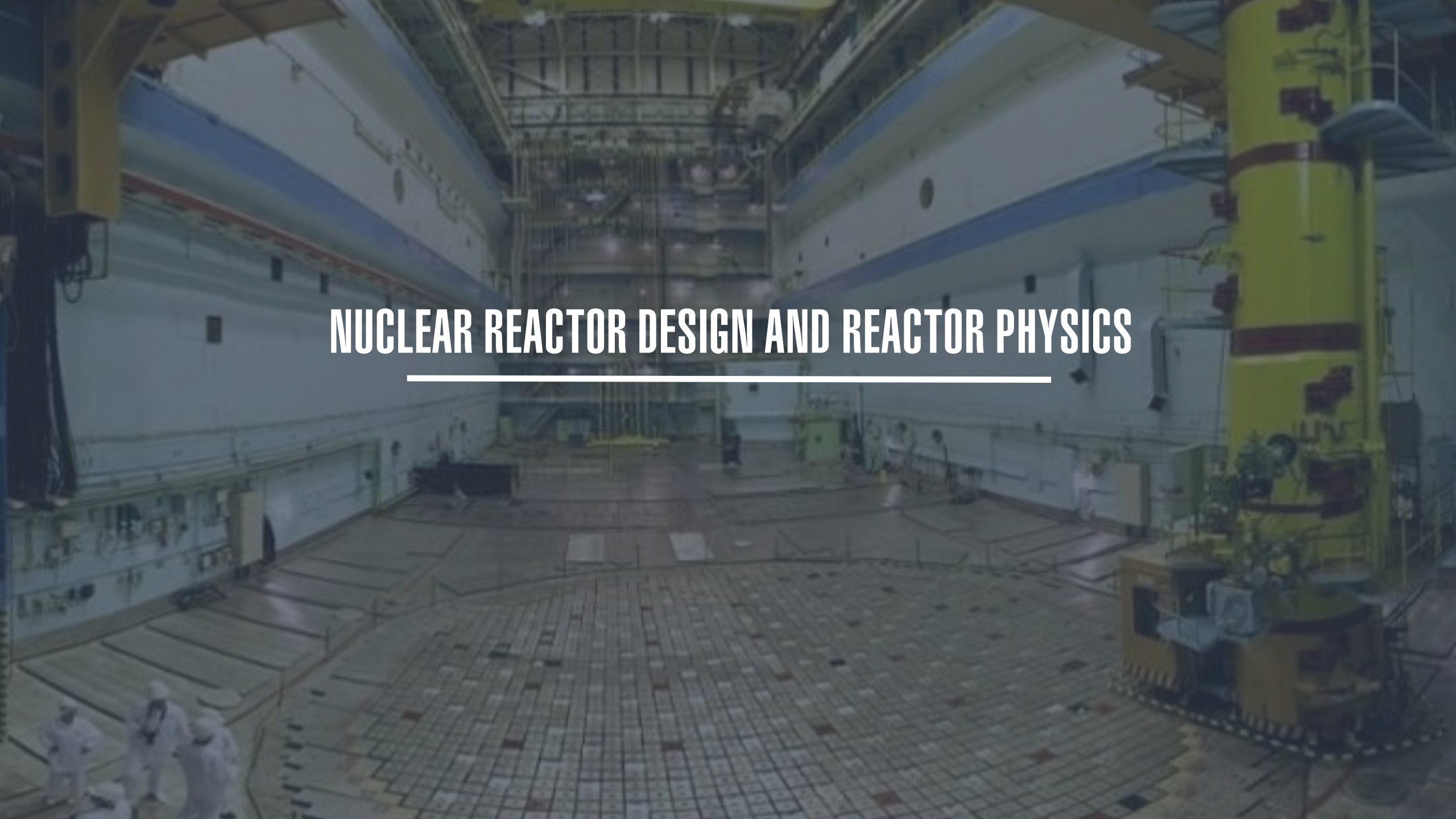
THE GEOGRAPHY AND HISTORY OF THE CHERNOBYL NUCLEAR POWER PLANT


Slavutych-
Semikhody
train
Pripyat
River
Pripyat
UKRAINE
BELARUS
UKRAINE
ChNPP
The “island”:
Units 5-6
construction
site
ChNPP cooling
reservoir
Chornobyl
Kiev,
180 km
Slavutych
Красное
Nedanchychi
Неданчичі
Tsentral'ne
Центральне
Kirava
Кірава
Mn'ov
Мньов
Kamaryn
Камарын
Staryk
Старик
Zahatka
Загатка
Hdzień
Гдзень
Borovyky
Боровики
P35
P56
P56

EVENTS AT CHERNOBYL

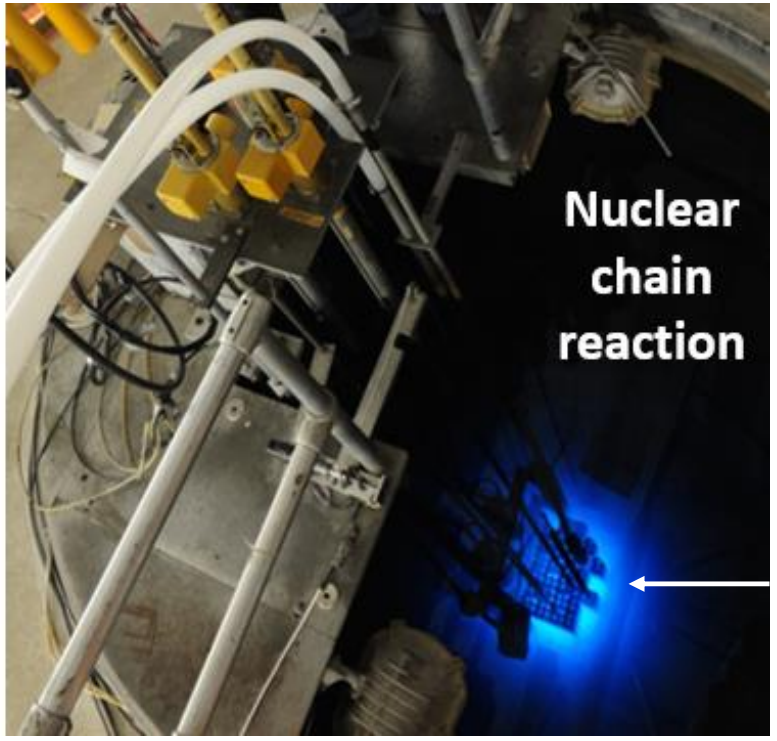



4
3
2
1



NUCLEAR REACTOR DESIGN AND REACTOR PHYSICS

CHAIN REACTING SYSTEMS



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

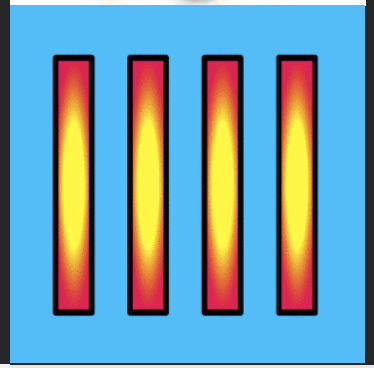
Fuel is combustible material that reacts with air when exposed to heat, producing more heat, which can cause combustion in additional fuel.

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

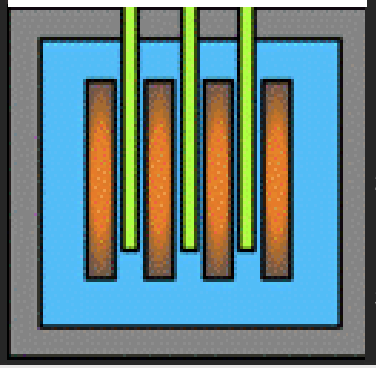
CONTROLLING FIRES

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.

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 neutron transport, including moderation (separation of fuel pieces), neutron leakage (shape and size of the system), and availability of 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***

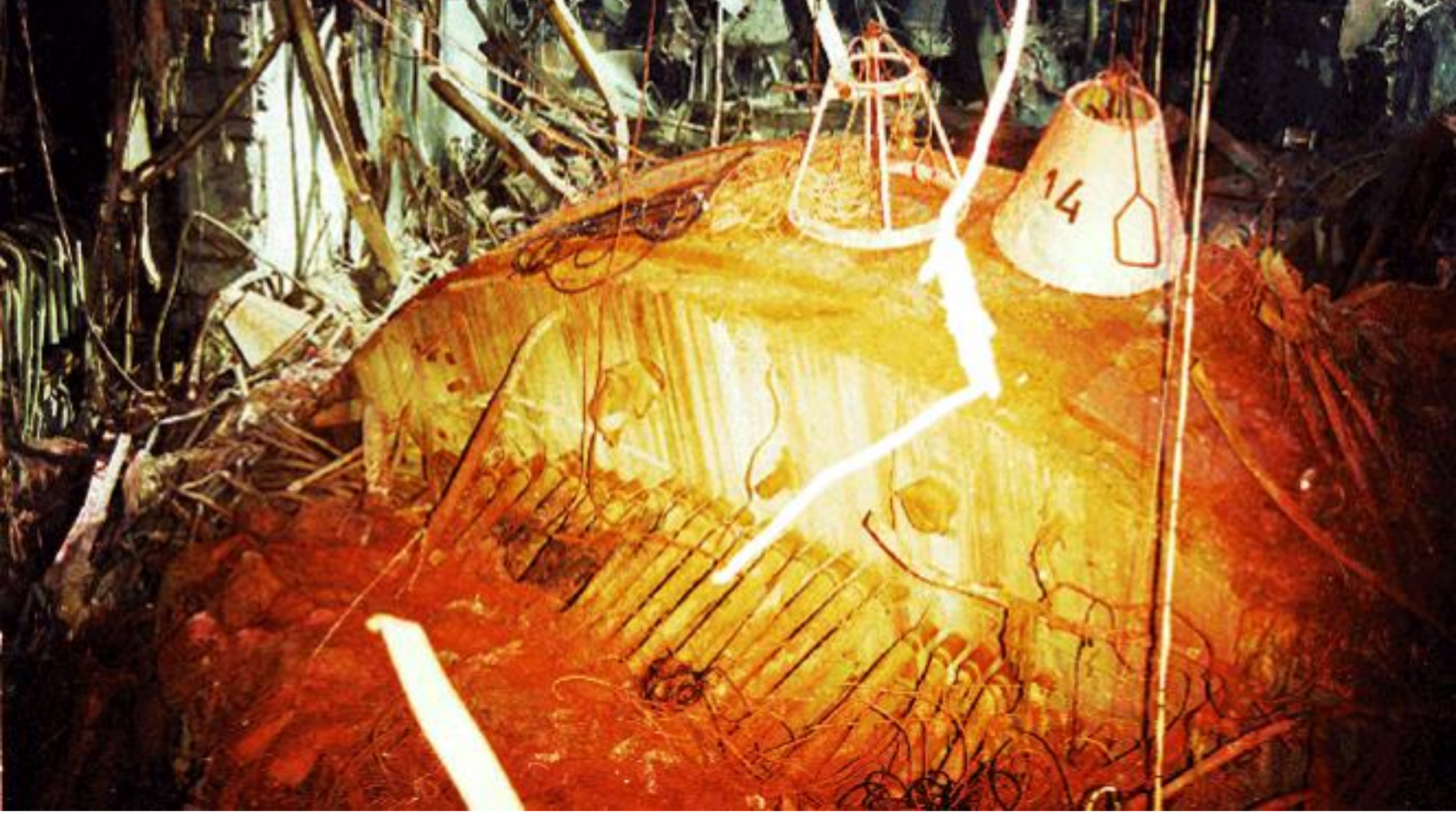
CHAIN REACTING SYSTEMS

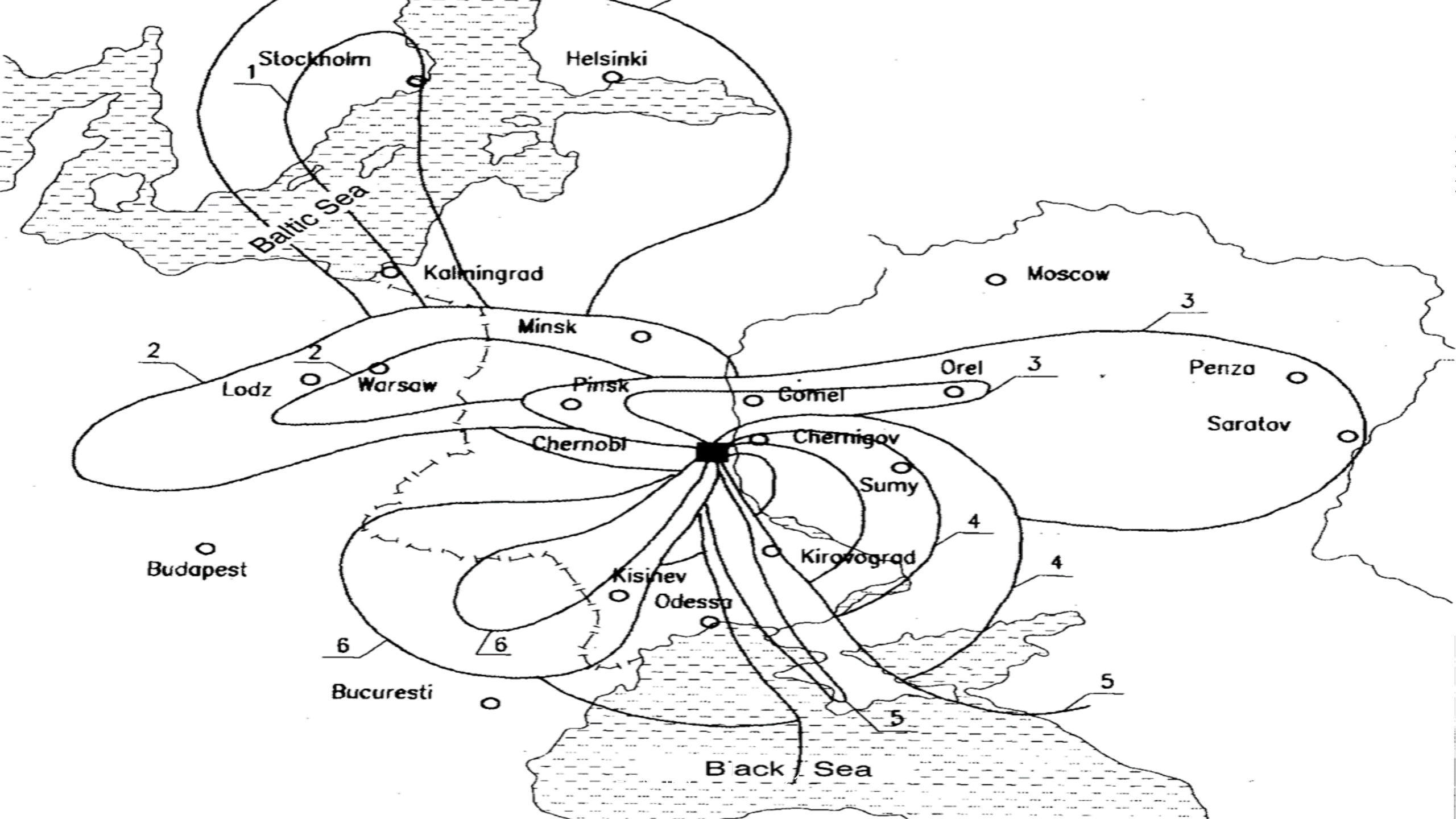
The operator withdrew most **control rods** to counteract **poisoning**, leading to **positive power reactivity feedback** as water boiled in the core. When the operator attempted to replace the control rods, their **tips accelerated the power surge** and control was lost.

CONTRIBUTING FACTORS

OPERATOR	DESIGN	SAFETY	RISK
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.	**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.	**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.	**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


14


Stockholm
Helsinki
Baltic Sea
Kalmingrad
Moscow
Minsk
Lodz
Warsaw
Pinsk
Gomel
Orel
Penza
Saratov
Chernobl
Chernigov
Sumy
Budapest
Kirovograd
Kisinev
Odessa
Bucuresti
Black Sea
1
2
3
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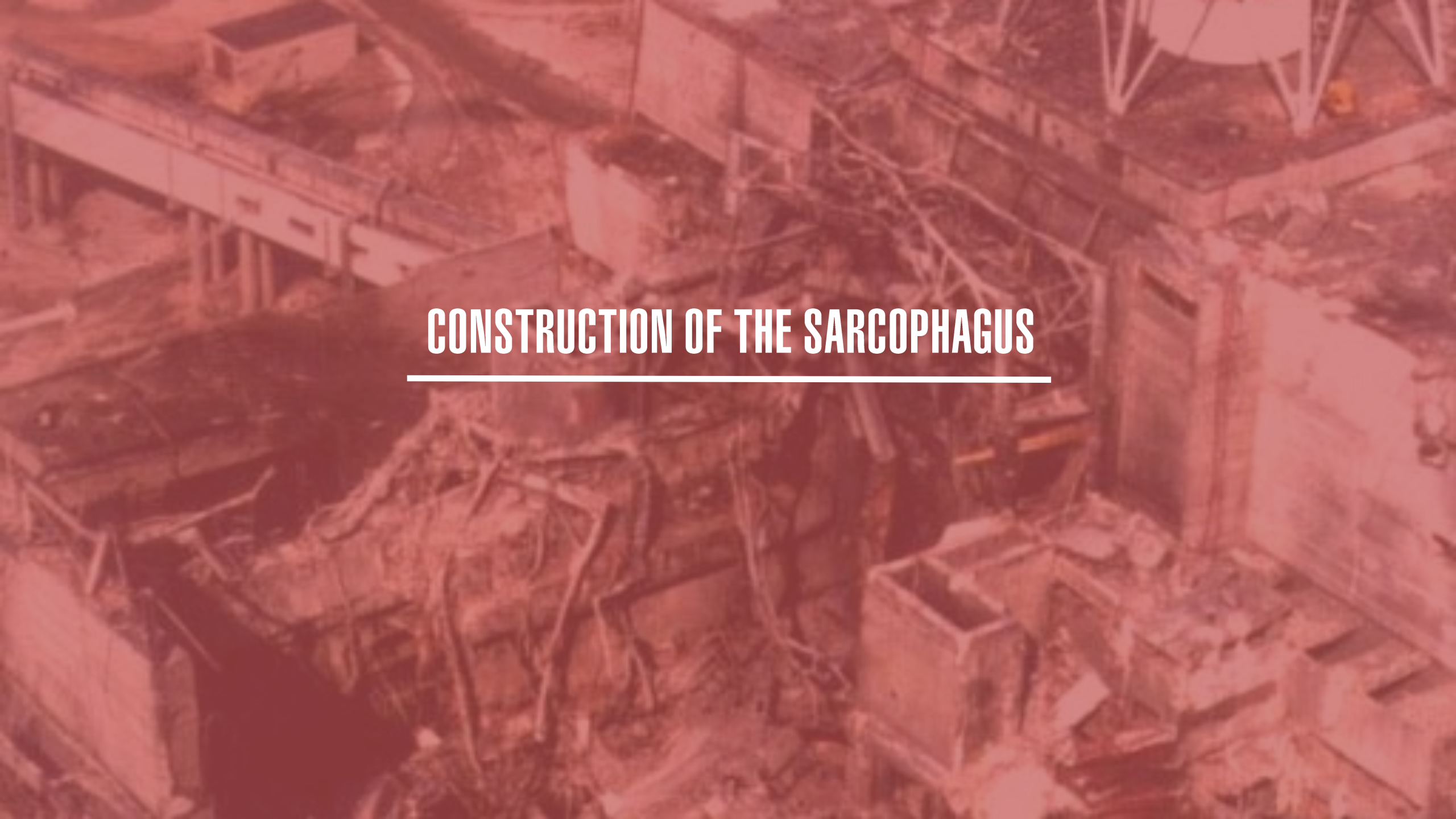
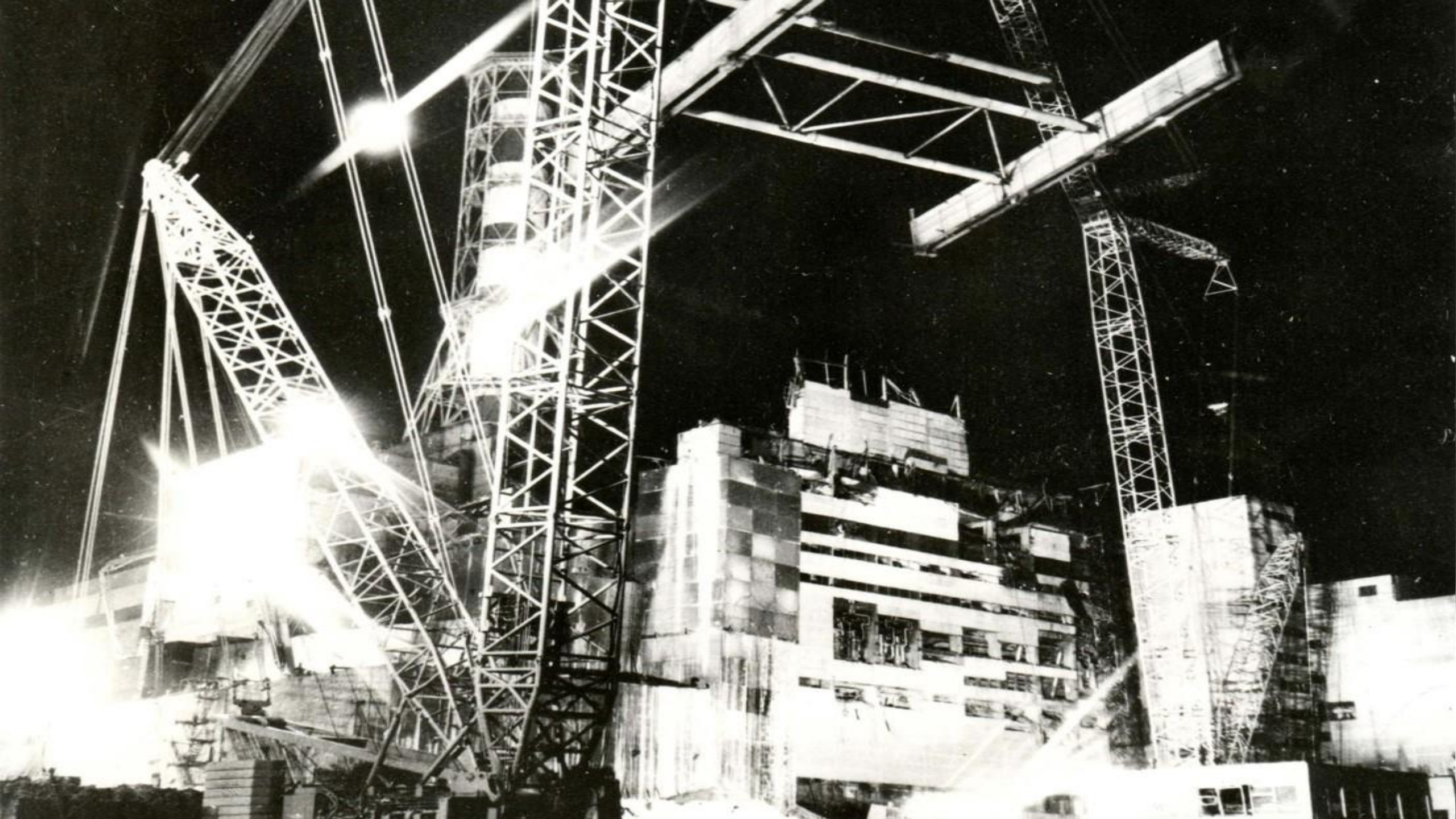
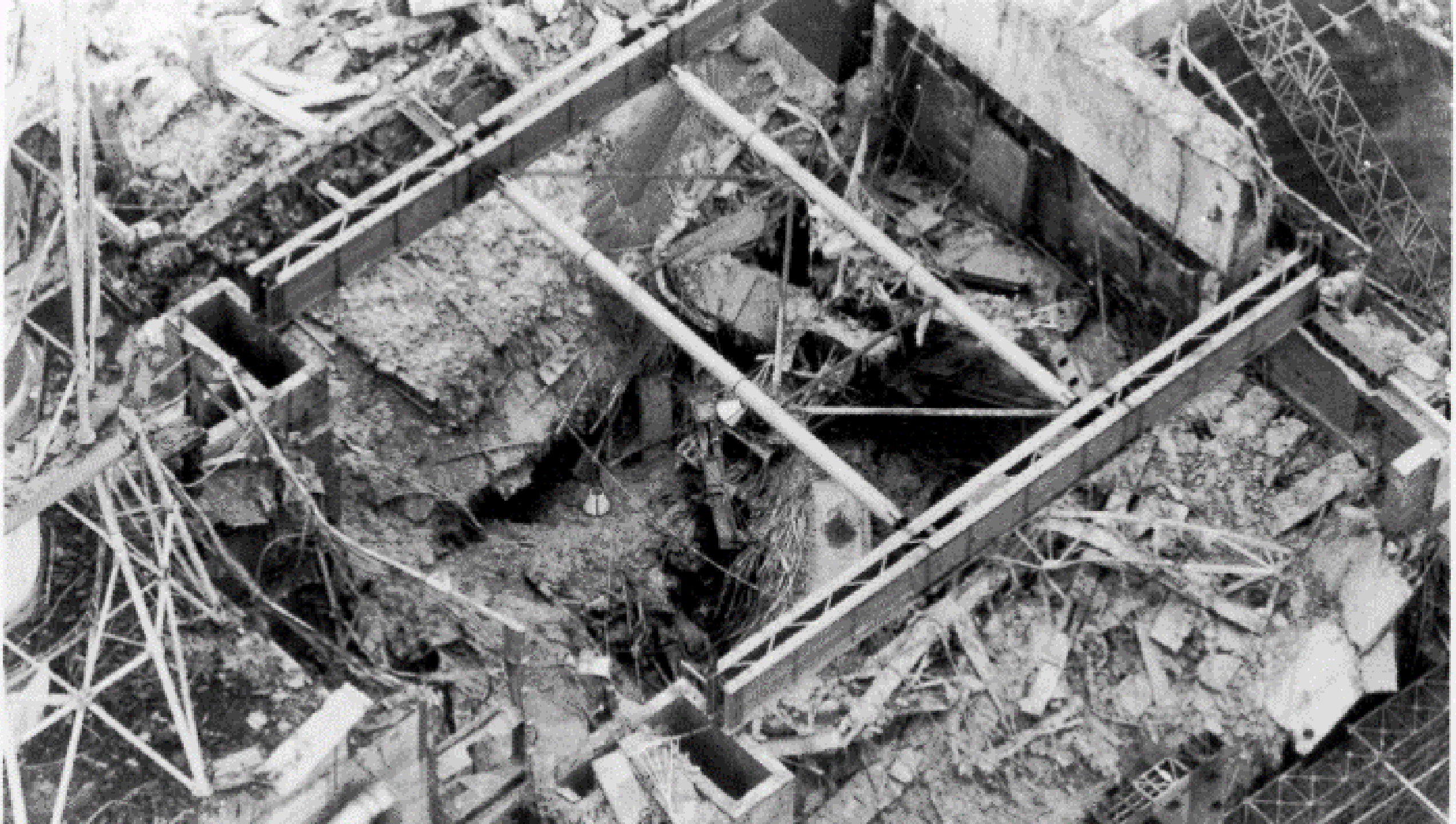
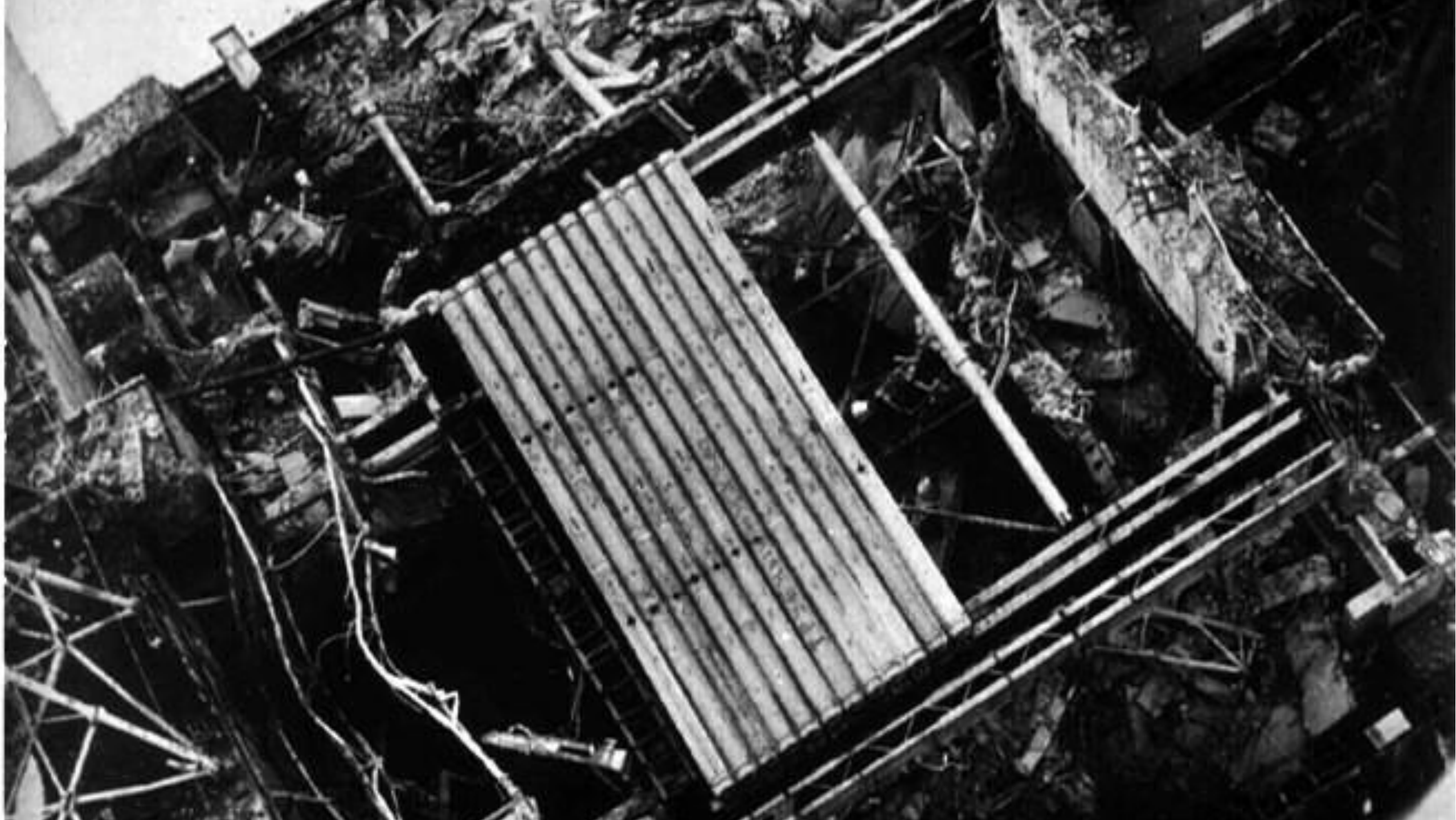
5
6

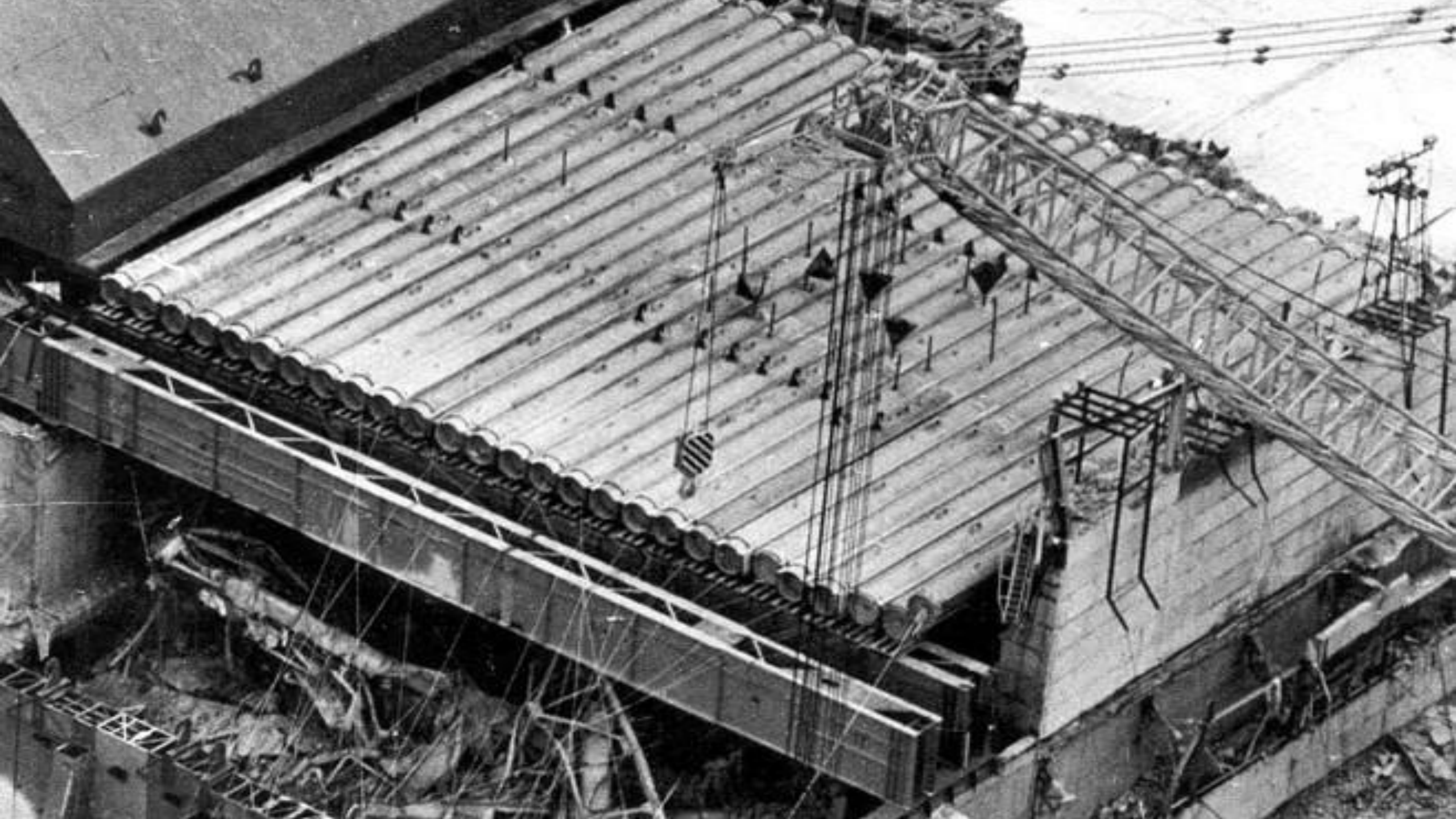


CONSTRUCTION OF THE SARCOPHAGUS





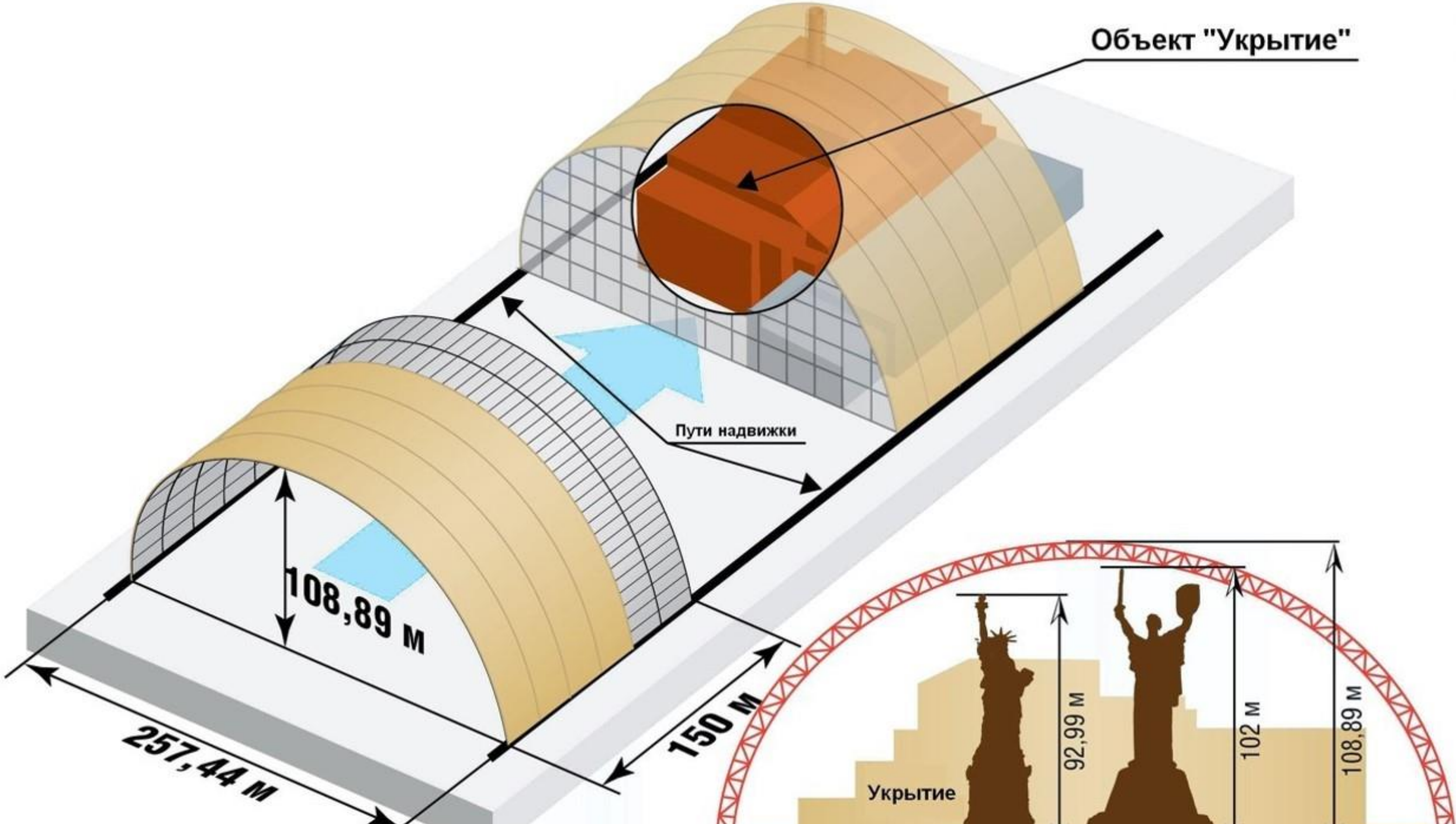


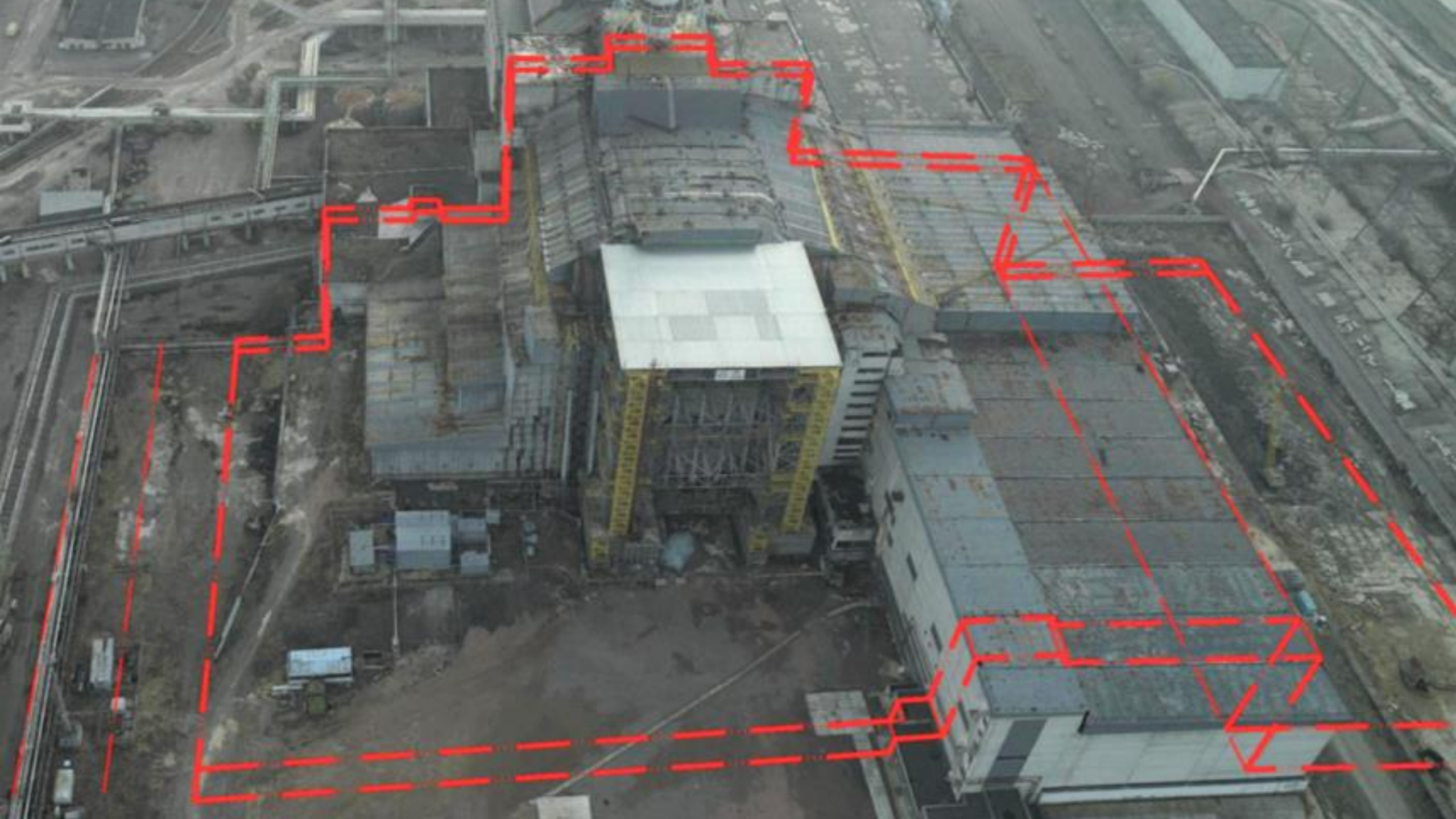


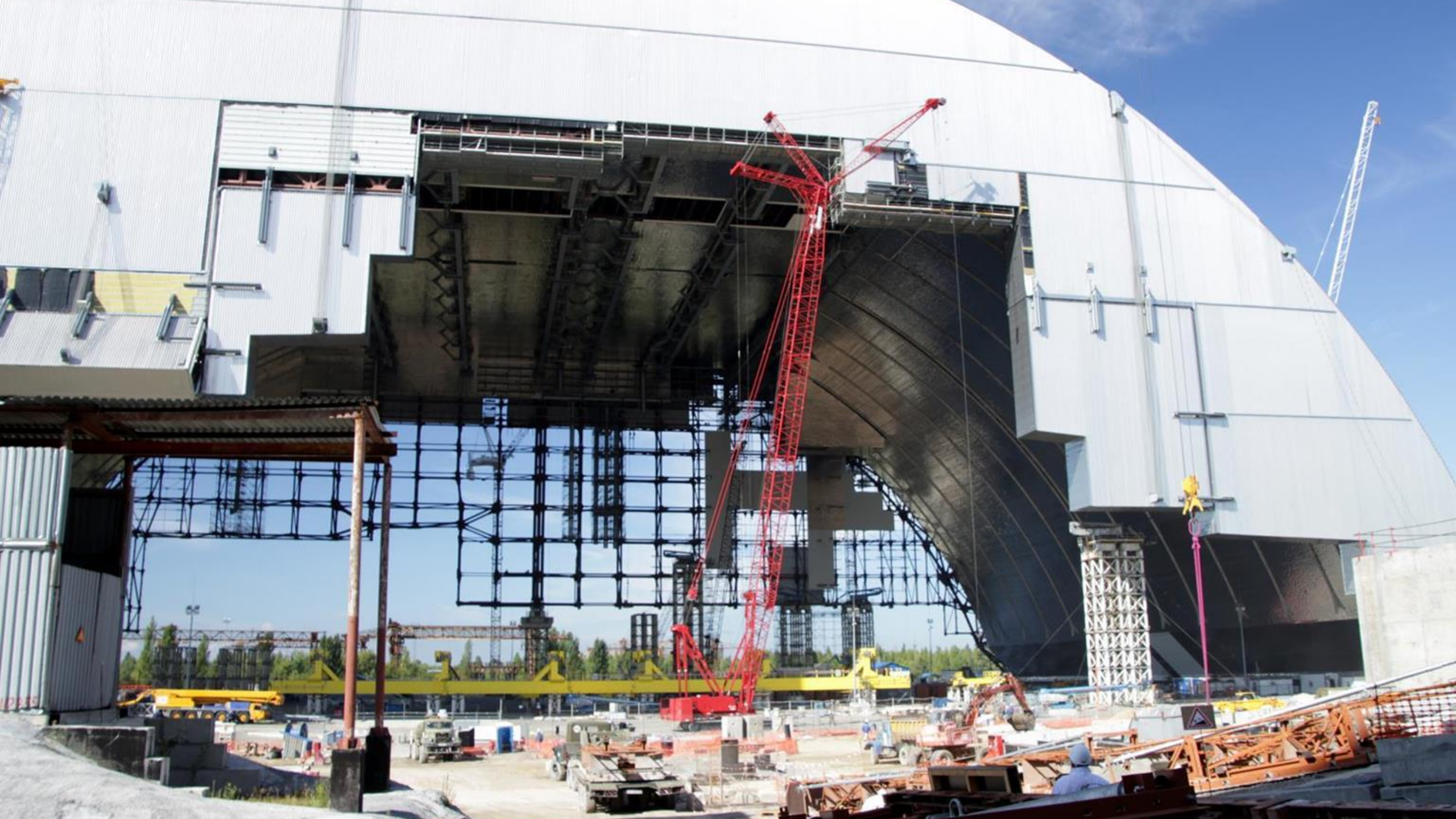

ЗАДАНИЕ ПРАВИТЕЛЬСТВА ВЫПОЛНИМ !


п. 914-2
O
N
S
W

NEW CONFINEMENT STRUCTURE


Объект "Укрытие"
Пути надвижки
108,89 м
257,44 м
150 м
Укрытие
92,99 м
102 м
108,89 м





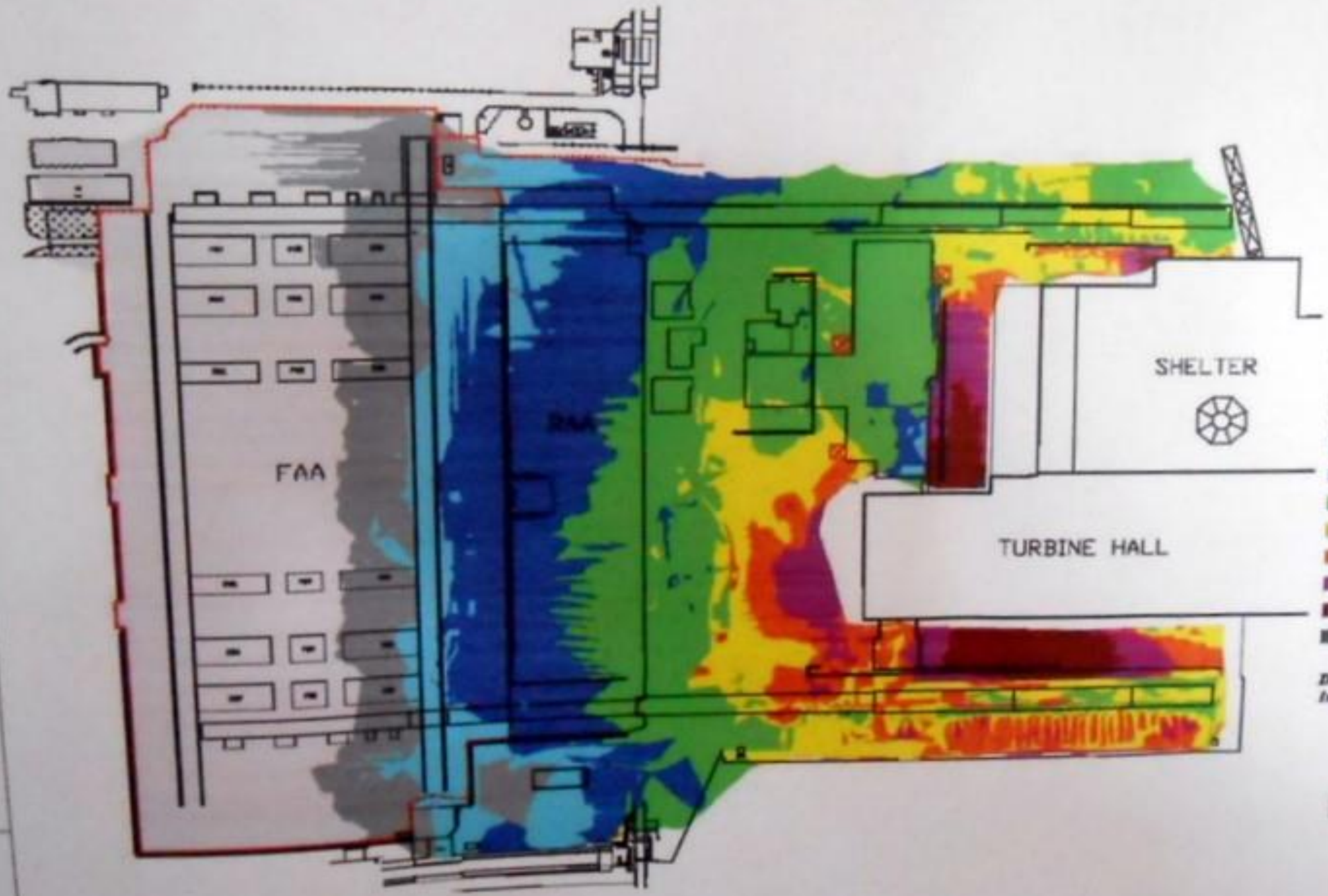

Genie S-125


MAMMOET

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 6086
Valid until 17/06/2015

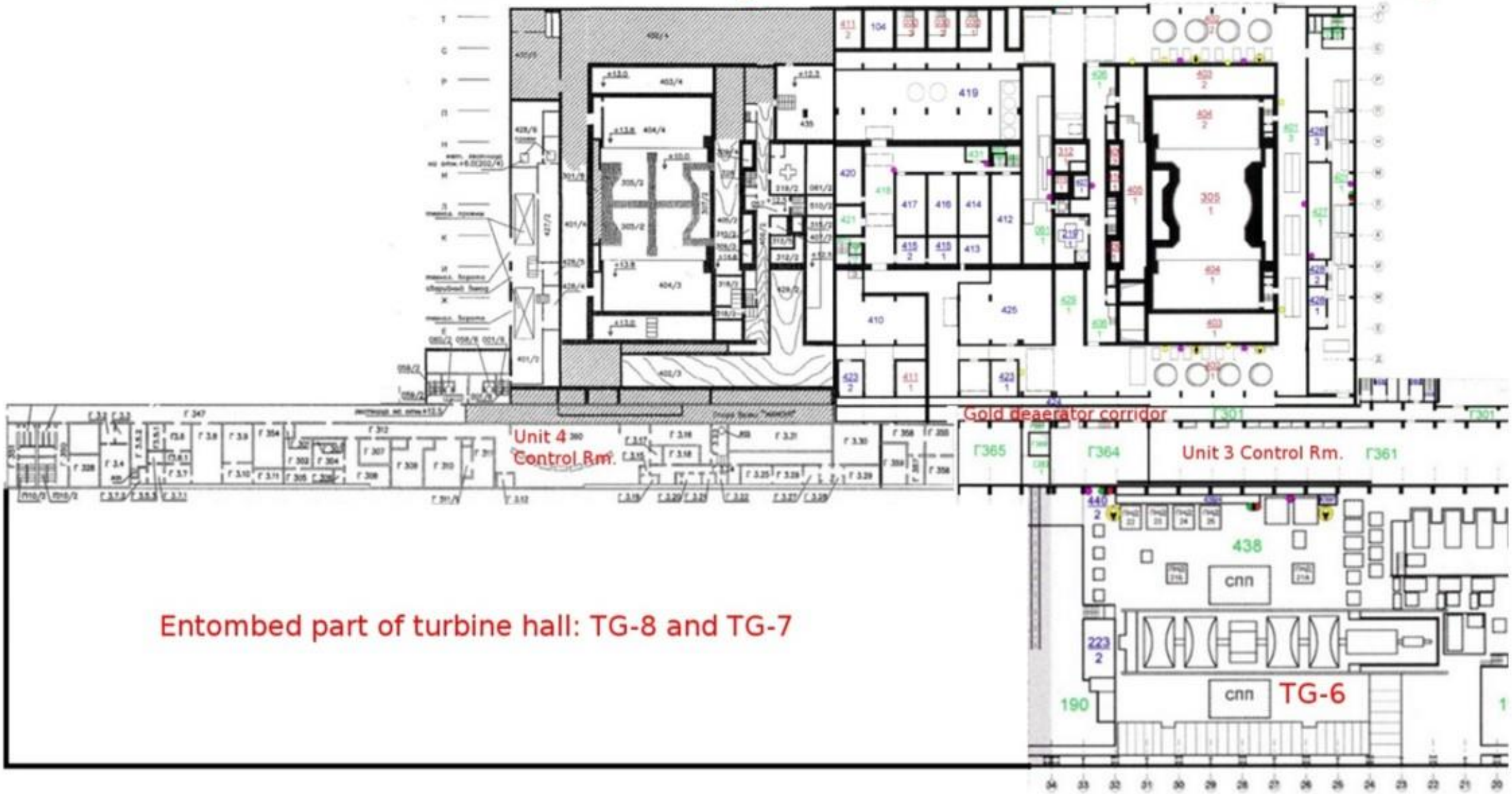
МАД / ADR
(Y): мкЗв/ч / μSv/h

< 0.5
0.5 – 3
3 – 7.5
7.5 – 15
15 – 30
30 – 45
45 – 60
60 – 150
150 – 300
>300

Dose rate measured at 1m above the ground

NOVARKA


KOREA
KUWAIT
LUXEMBURG
NETHERLANDS
NORWAY
POLAND
PORTUGAL
SLOVAKIA
ПЛАН ЗДІЙСНЕННЯ ЗАХОДІВ НА ОБ'ЄКТІ "УКРИТТЯ" (SIP)
НОВИЙ БЕЗПЕЧНИЙ КОНФАЙНМЕНТ (НБК) ОБ'ЄКТА "УКРИТТЯ"


Unit 4 Reactor Building
Vent. Building
Unit 3 Reactor Building
Unit 4 Control Rm.
Gold deaerator corridor
Unit 3 Control Rm.
Г365
Г364
Г361
Г301
438
cnn
cnn
TG-6
190
Entombed part of turbine hall: TG-8 and TG-7


EOS DIGITAL
Canon
SCHOLZ


Model 26
LUDLUM MEASUREMENTS INC
999
kcpm
SN: PF003242


A3
MIG-4131
Model 26
3650


51

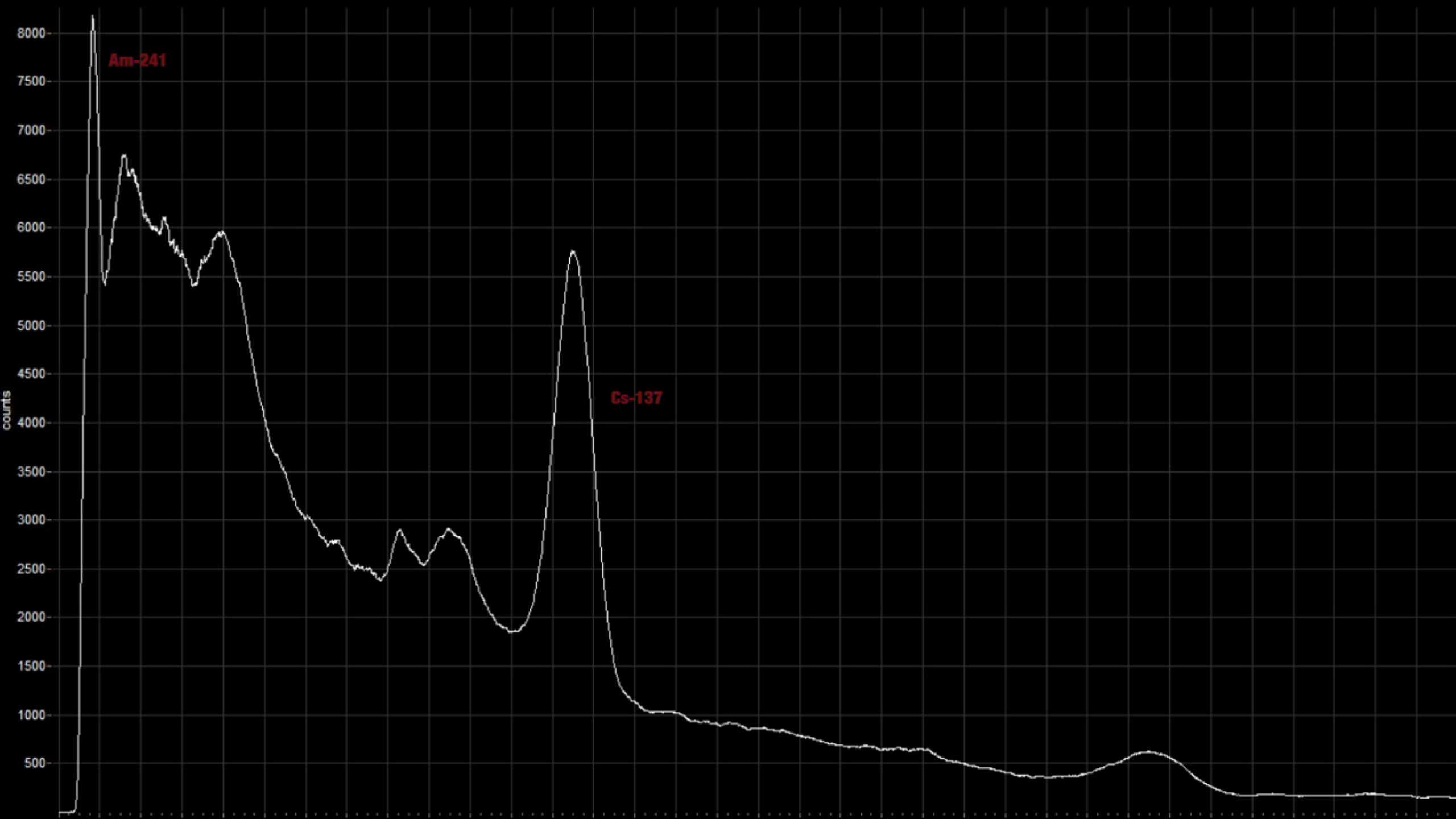
REDUCING WORKER EXPOSURES


HILTI


ONLY
4
ПРОХОД
ЗАКРЫТ


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


Am-241
Cs-137
counts
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500

CHERNOBYL INTO THE FUTURE


5


N
W


O
W
N


W
S
N
O
пом. 217-2


пом. 217-2
S
W
N
O


THE WORKERS OF CHERNOBYL


RЖД
ЭР9Т - 673


«ЧИСТЫЙ» МАРШРУТ
«CLEAN» WALKWAY


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

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Lucas W. Hixson

Carl Willis

Heidi Baumgartner

Dr. Sonja Schmid

The Chernobyl Nuclear Power Plant