



## Accident at Russia's Biggest Hydroelectric



Sayano-Shushenskaya – 2009 August 17



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Brasil – 2009 Aug 24



## **Objective**

This presentation aims to disseminate some technical and general aspects of the accident. A long and detailed work must be done in order to provide understanding about what happened, in order to help all Owners to prevent such accidents.

## **Note**

This is a preliminary analysis made based only on pictures and films, done no longer than one week after the accident. Only hypotheses are formulated.

# 1- Main Characteristics

- Number of Units: 10
- Turbine Type: Francis (16 blades)
- Rated Power: 650 MW each
- Rated Discharge per Unit: 358,5 m<sup>3</sup>/s
- Nominal Speed: 142,86 rpm
- Net Head: 194 m
- Operation Date: 1978
- Runner Weight: 156 ton
- Runner Diameter: 6,77 m



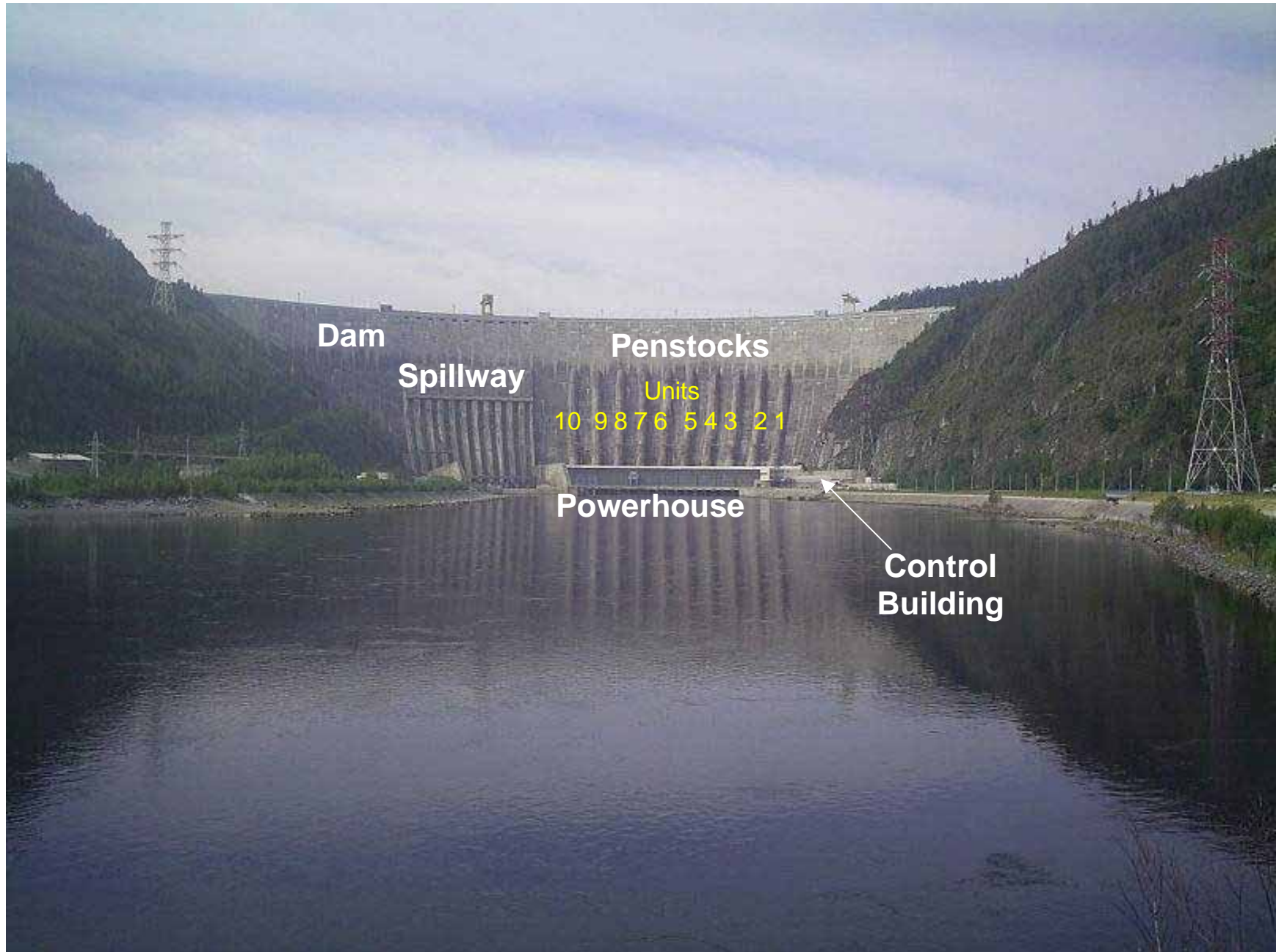


## 2 - Main Characteristics

One of the world's largest hydro-electric plants, its dam is 245 m (800 ft) high and stretches 1 km (0.6 miles) across the Yenisei river.

Opened in 1978, the station provides a quarter of RusHydro output and is a major power supplier to at least two smelters owned by United Company RUSAL, the world's largest aluminium producer.

The hydroelectric power station is located on the Yenisei River, near Sayanogorsk in Khakassia, Russia. Before the accident, it was the largest power plant in Russia and the sixth-largest hydroelectric plant in the world.



**Dam**

**Spillway**

**Penstocks**

**Units**

**10 9876 543 21**

**Powerhouse**

**Control Building**



Spillway

Penstocks

Transformers

Lines

Powerhouse



## The accident

At 08:13 local time (00:13 GMT) on 17 August 2009, the station suffered a catastrophic "pressure surge" in turbine known as a water hammer. The sudden water pressure surge resulted in the ejection of turbine 2 with all equipment, a total weight some 900 tons, from its seat.

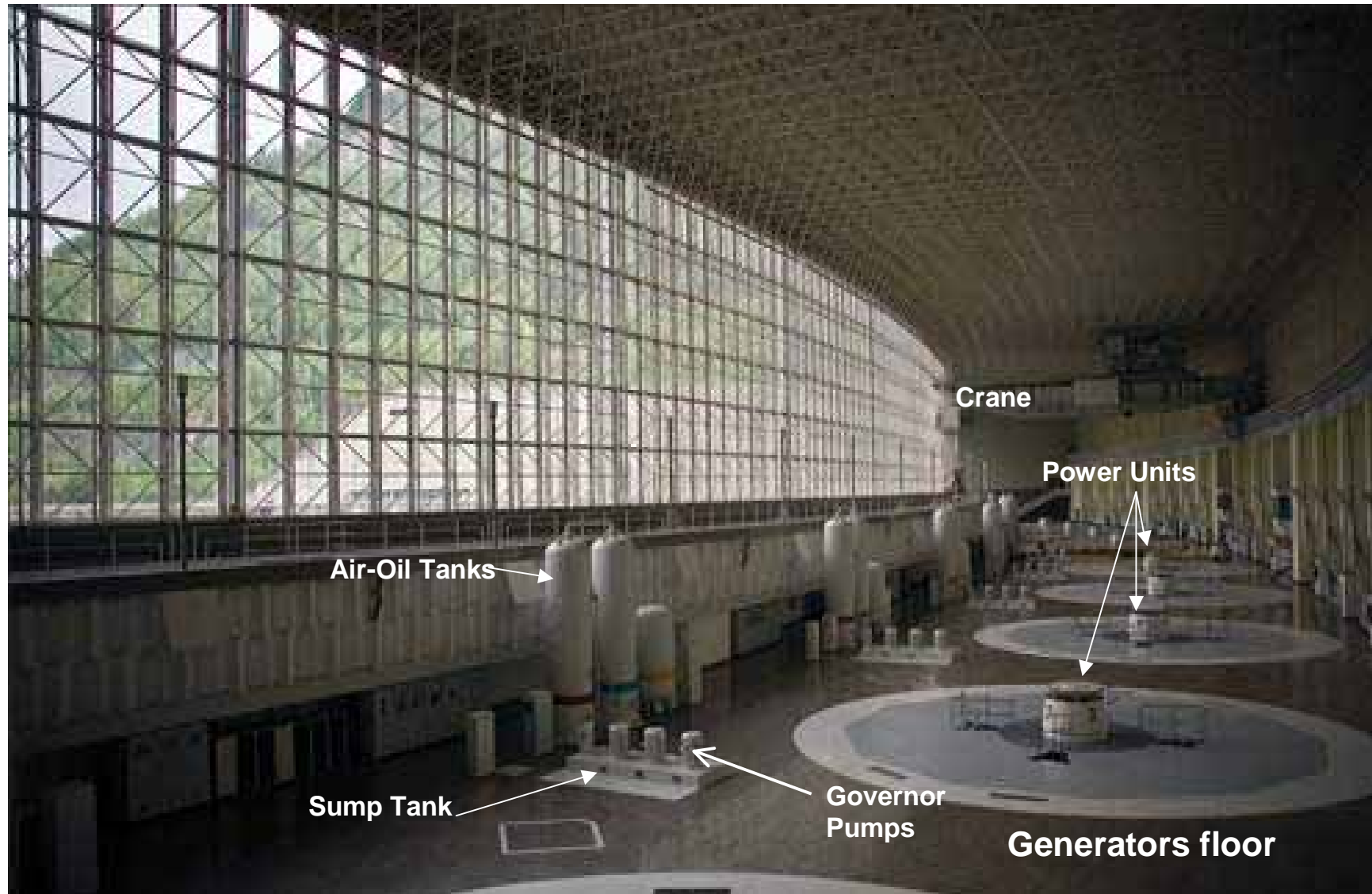
Turbines 7 and 9 also suffered from severe damage, while the turbine room roof fell on and damaged turbines 3, 4 and 5. Turbine 6, which was in scheduled repair at the time of accident, received only minor damage as it was the only one of the station's 10 turbines that did not receive electrical damage due to shorting of transformers, and it will be restarted as soon as possible.

Water immediately flooded the engine and turbine rooms and caused a transformer explosion.

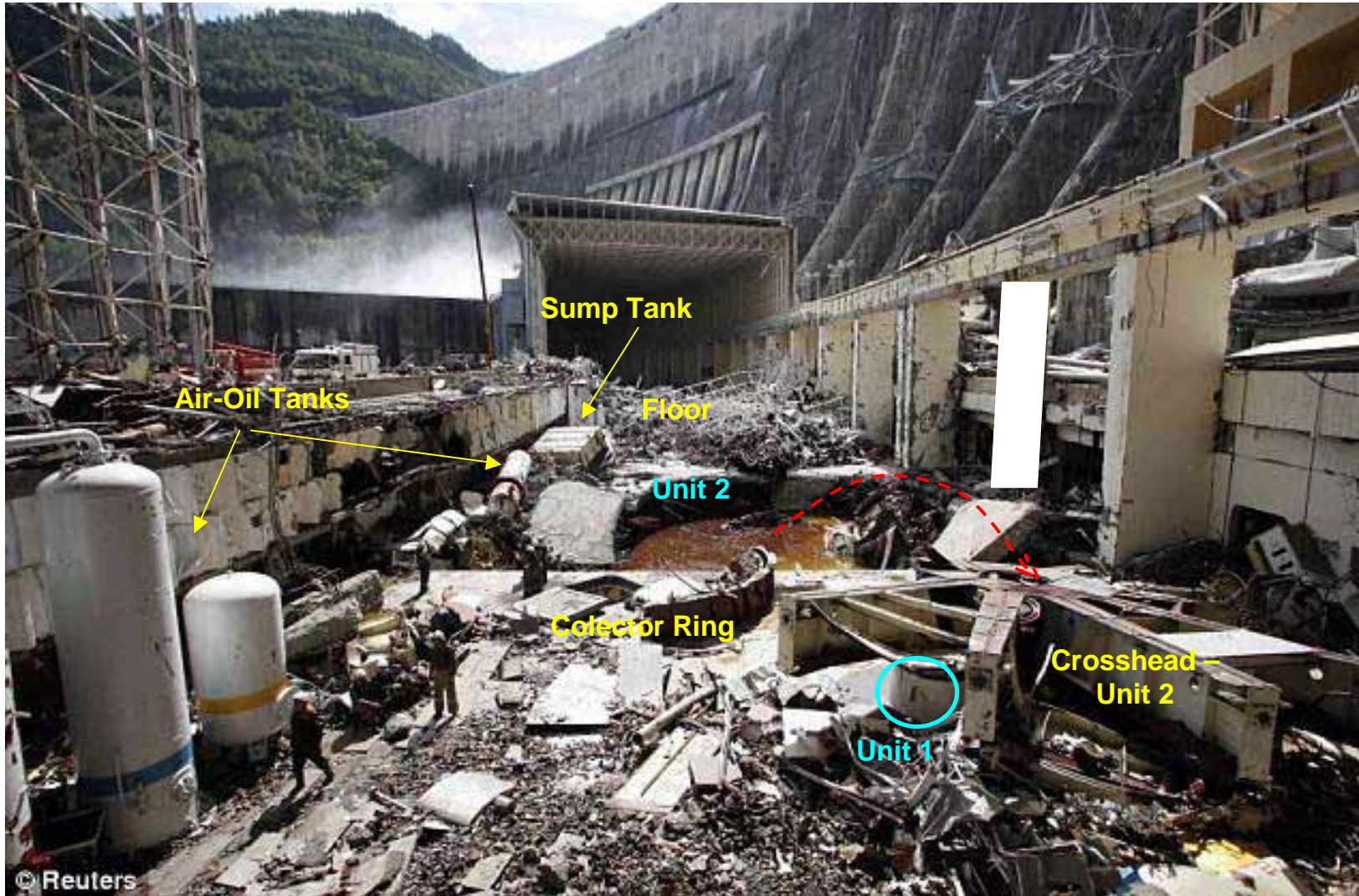
**On 23 August 2009**, authorities said 69 people were found dead while 6 people are still listed as missing. Efforts to pump flood water from the engine room and complete a search for the missing workmen are expected to take 3 to 8 days.



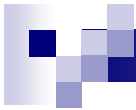
# Before the Accident



# After the Accident

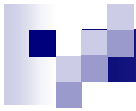


*Generator floor*



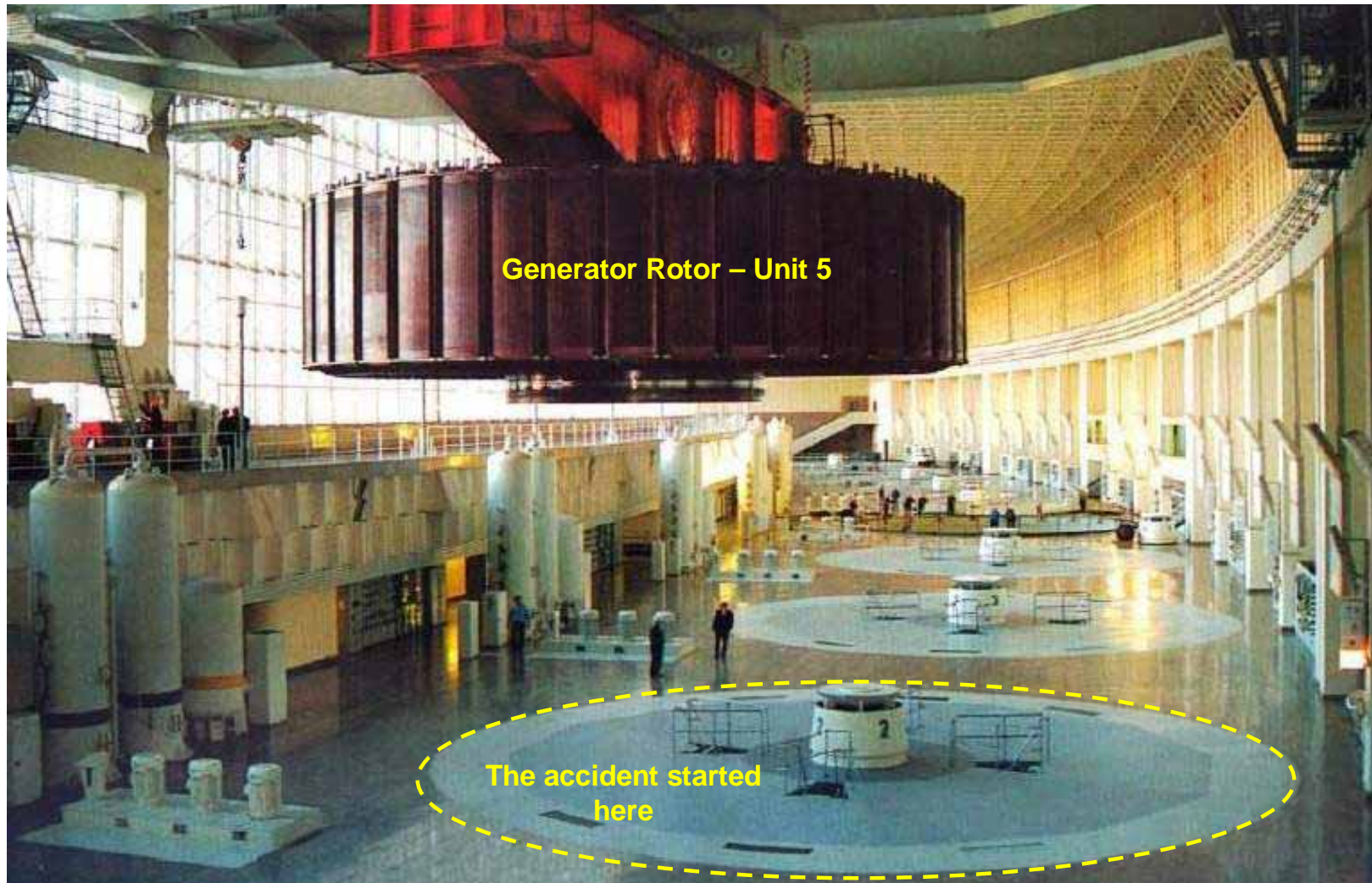
Floor

*General View*

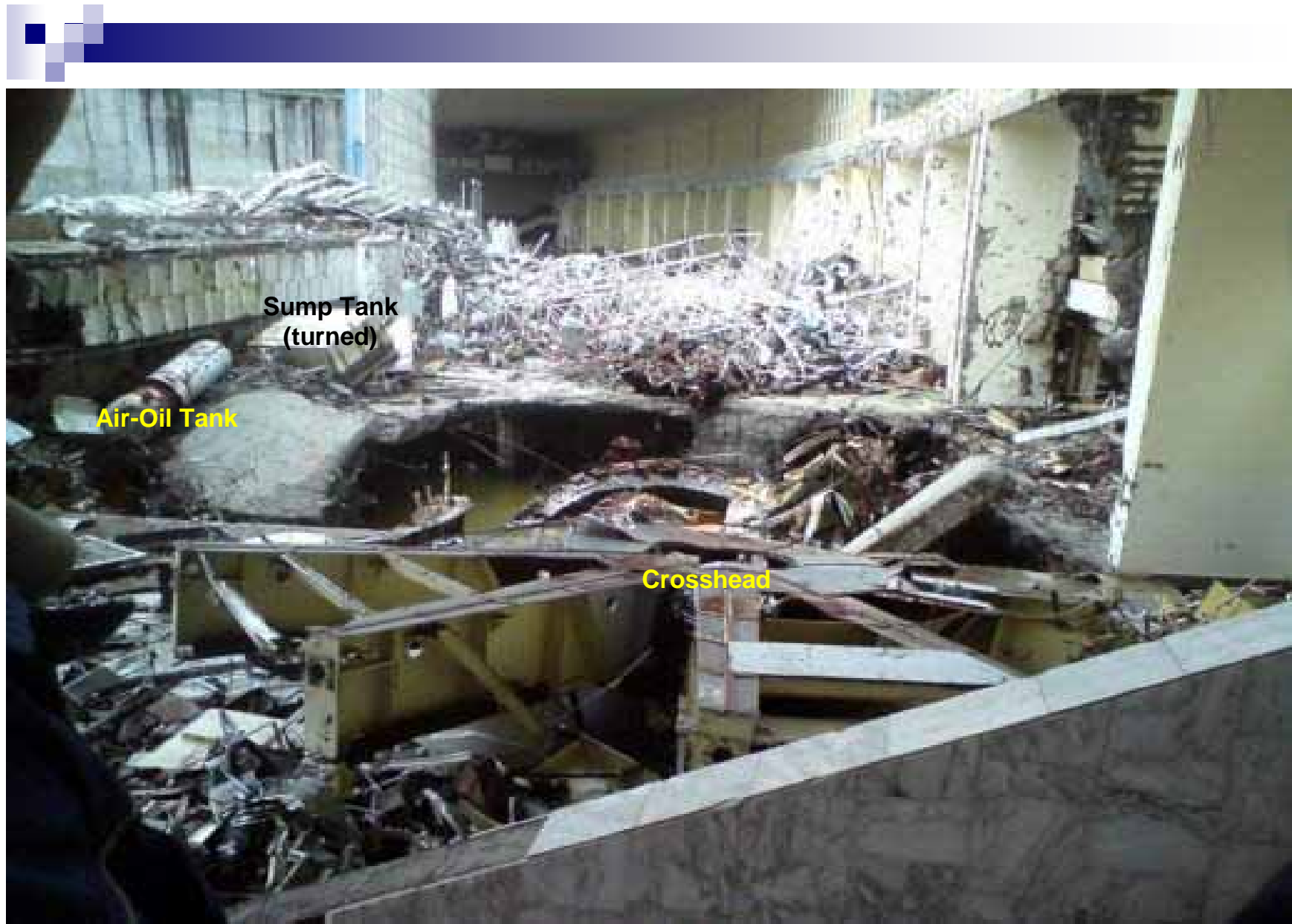


*General View*

## Before the Accident



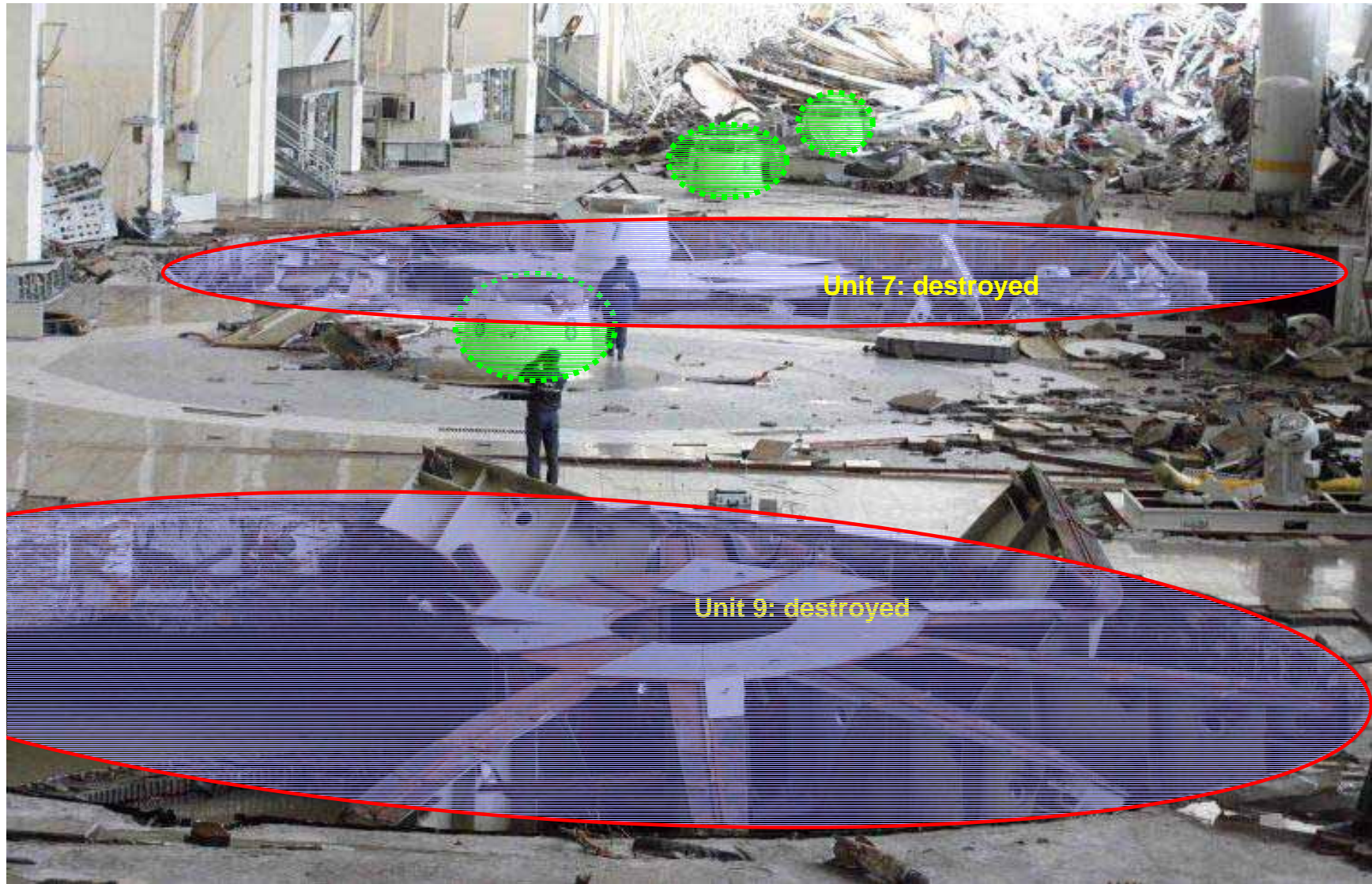
*Generator Runner*

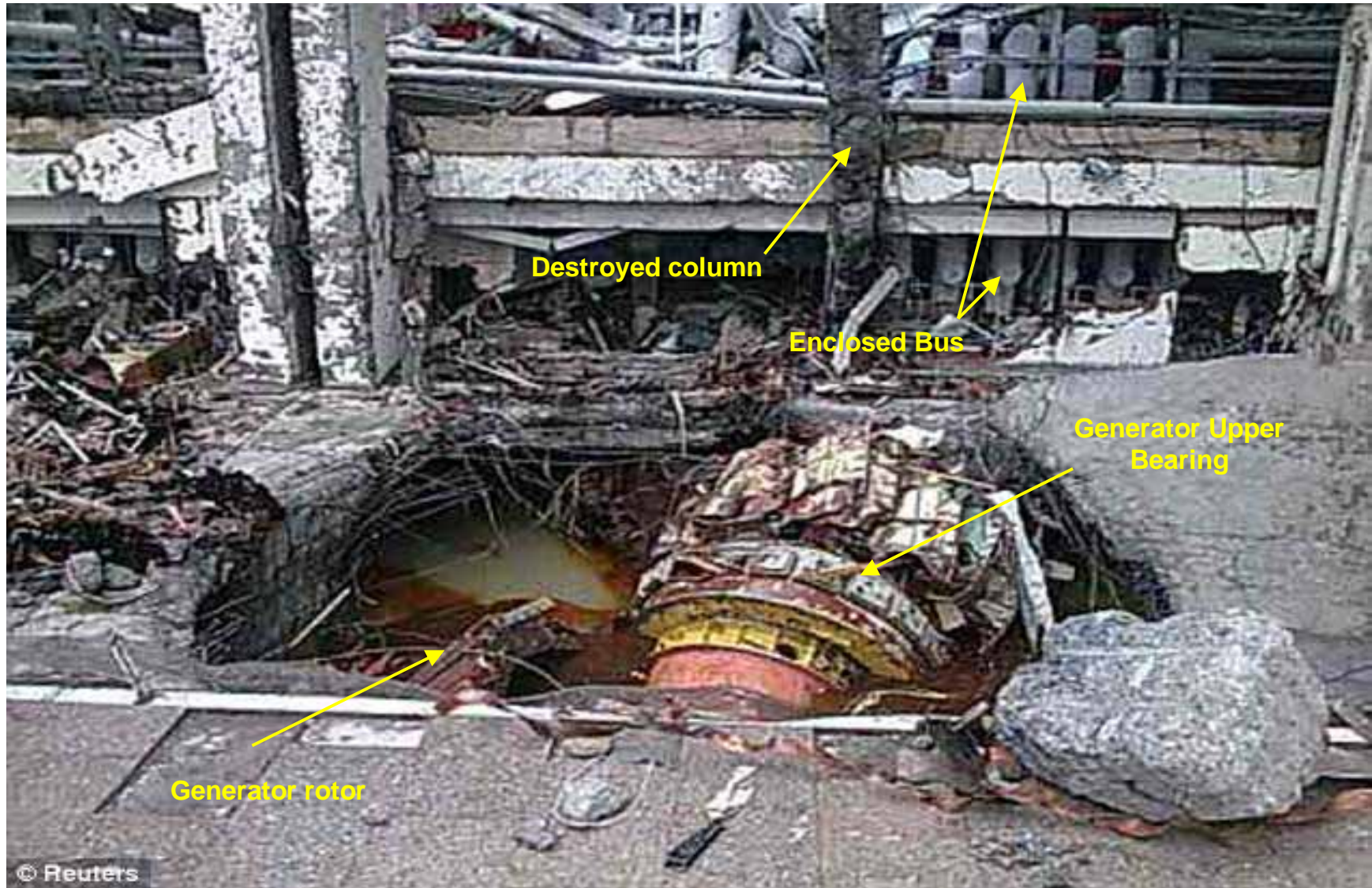


Sump Tank  
(turned)

Air-Oil Tank

Crosshead





Destroyed column

Enclosed Bus

Generator Upper Bearing

Generator rotor



# Consequences

- 76 people dead.

Question: By this number, maybe there was approx. 100 people in the Powerhouse. Normally, even during maintenance works, there aren't so many people. Why was there so many people?



# Consequences

- It will cost at least \$310 million.
- A long time to repair the damages.
- The production of more than 500,000 tons of aluminum will be lost.
- Oil slick is travelling down the river.



# Consequences



- The plant satisfied 10% of Siberia's energy needs.
- Aluminum smelters consumed over 70% of the energy generated by the power plant.

- It is not clear how many people were potentially affected by the accident.





# 1 - Causes

Our main hypotheses about the sequence of the disaster:

(Attention: Preliminary hypotheses based only on the pictures)

- Sudden closing of the Unit 2 wicket gates.
- Heavy waterhammer in the spiral case and penstock, causing their collapse.
- Upward force, resulted from the waterhammer, destroying the civil structure over the spiral case and penstock.
- Pressure of the upstream water causing elevation of structures and peaces.
- Heavy reverse waterhammer (draft tube) causing elevation of the turbine cover, shaft, etc.
- Rapid flooding of the Powerhouse.
- Units 7 and 9, without closing, in runaway speed with the generators inside the flood water.



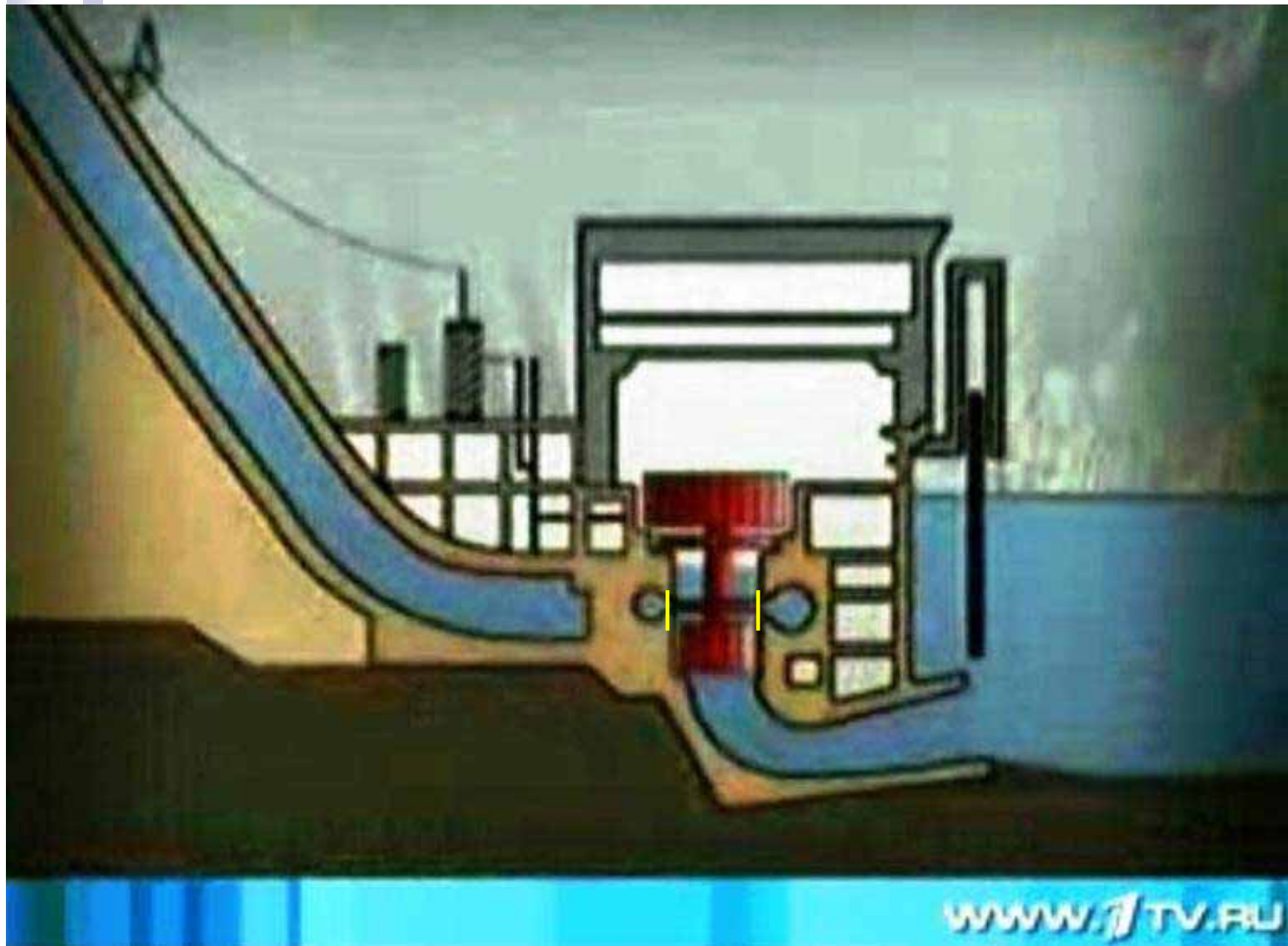
## 2 - Causes

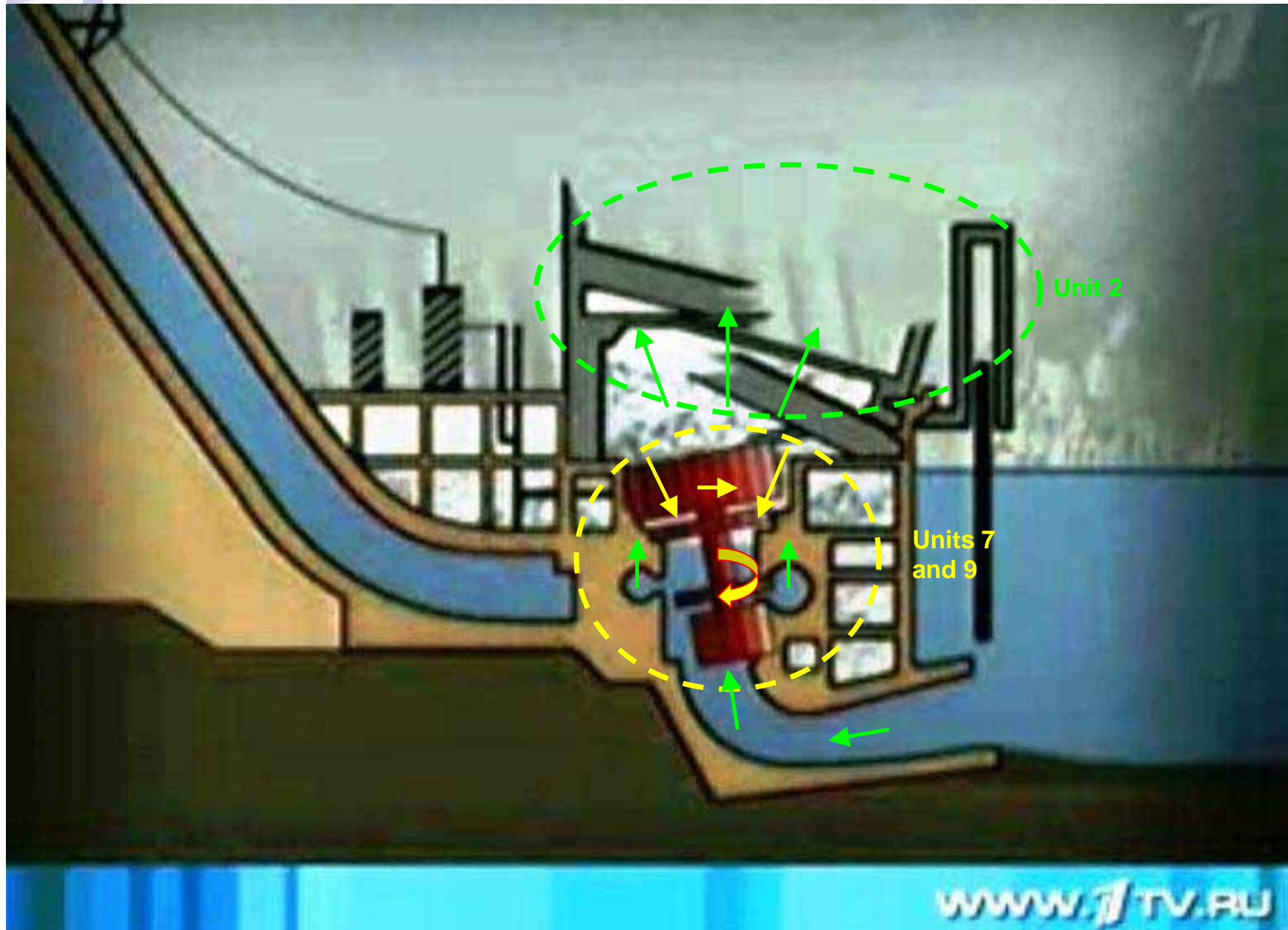
Our main hypotheses about the cause of the sudden closing:

- A large piece entered in the turbine runner and stuck in it (could not pass the exit of the blades, which is of smaller dimensions).
- This piece turned with the runner and hit all the wicket gates, causing their sudden closing, at a fraction of a second.
- This piece could be: a log (passed by an opening in the trashrack), stay vane or wicket gate broke.

Or (less probably):

- Rupture of the governor oil pipe in the closing side of the distributor servomotors (in this case, the orifice that controls the oil flow should be in the pipe and not in the body of the servomotors).
- Rupture in sequence of the wicket gates links; closing by hydraulic tendency.







# Some Next Steps

- Continuing the seeking of victims.

and

- Finishing the cleaning of the debris.
- Completing the drainage of the water.
- Constructing a temporary roof (one week) and then a better one (two months or less) to protect against the winter (this will prevent new photos...).
- Recover the columns and beams supporting the rails of the Powerhouse Crane, to allow its use.





# News – August 21

- NOVOSIBIRSK, August 21 (Itar-Tass) - The water level in the inundated turbine room of Sayano-Shushenskaya hydropower plant where the water pumping out was started on Thursday, decreased by 2 meters by Friday morning
- A total of more than 30 thousand cubic meters of water have been pumped out. It is necessary to pump out a total of 250 thousand cubic meters of water.
- Minister Sergei Shoigu earlier set the task to install additional pumps and thereby increase the volume of pumped out water to 4 thousand cubic meters per hour. “By increasing the capacity we will fulfill this task (water pumping out) in 32 hours,” the minister said.
- Thirteen pumps have been put into operation in the water pumping efforts at the plant. The debris clearing operation continues. According to latest reports, 4,650 cubic meters of reinforced concrete structures have been moved out from the hydroelectric station.
- At present, about 2 thousand people and 116 machinery units are engaged in the Sayano-Shusehnskaya HPP catastrophe liquidation efforts.

<http://itar-tass.com/eng/level2.html?NewsID=14255520&PageNum=0>

# Some References

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