NHK World, Documentary, (Fukushima), 2012-08-18 Gordon Taylor 2014-01-13
'The truth behind the chain of meltdowns' [49:56] http://www.youtube.com/watch?v=vpA0TOgB9-o

[Narrator].'This is the Fukushima Daiichi Nuclear Power plant, operated by Tokyo Electric Power Company. Decommissioning it will likely take some 40 years. The long journey has just begun.
(Extracting nuclear fuel, July 18, 2012).
'It's been nearly a year and a half since the disaster, one of the worst nuclear accidents in history, but many questions remain unanswered'.
(Tokyo).
'In mid-July, citizens staged one of the largest demonstrations in the country's history, to protest against nuclear power'.
[Demonstrator] 'I want to know why the government has allowed a nuclear plant to resume operation without confirming it's safety'.
[1:07]. (No more nuclear plants).
[Narrator]. 'Distrust has reached new heights'.

(Tokyo Electric Power Company (TEPCO)).
'What caused the accident ? Was it unavoidable ? After more than a year of negotiations, we were able to interview on-site managers, provided that we hide their identity. They all recounted a grave set of circumstances that defied imagination'.
(Reactor 2 crisis response chief).
'[1:41]. 'I was really scared. It was like living hell. I was thinking this could turn into another Chernobyl if worst came to worst'.
(On-site manager right after explosion).
'I saw things unfold with my own eyes, but none of it seemed real. It was like being in a war zone or something'.
[2:05] [Narrator]. 'Hydrogen explosions occurred at Reactors No 1 and 3, one after another. This was the first time a nuclear disaster had lead to meltdown of multiple reactor cores'.
[Graphic] (Meltdown).
[Narrator]. 'We interviewed over 300 people who dealt with the accident. Based on their testimony, we've re-enacted what happened during the crisis'.
(Quake-proof building (Emergency Headquarters)).
[2:45]. [Operator] 'Have you located the people who went missing after the Reactor 3 explosion ?'
'Over 30 still unaccounted for'.
(Reactor 2, Main control room).
('Open the SR Valve')
('Understood. Opening the SR valve...).
(Why isn't the pressure coming down ?)
[Narrator]. 'Our investigation revealed an unexpected fact that made the aftermath of the accident worse. It turns out a safety mechanism might have had the tendency to become harder to operate as the crisis worsened'.
(Safety mechanism).
[3:23]. 'Furthermore not just the tsunami but also the earthquake may have had a critical impact - though TEPCO has denied it'.
(Earthquake effects).
[3:32]. (Quake resistance specialist)
'Given the scale of the earthquake, it's possible some devices were not sufficiently quake proof. We can't deny the possibility that they suffered damage and caused leaks'.
[Narrator]. 'Are nuclear power plants really safe ? We asked the top executive at the Fukushima site.
(Top executive at Fukushima Daiichi plant)
'If we are to continue with nuclear power generation, I assume we'll be conducting safety assessments promptly'.
[4:10] (Radiation in the primary containment keeps on rising).
[Narrator] 'One after the other, three reactors at the Fukushima Daiichi nuclear power plant experienced core meltdown'.
[Title] (The Truth Behind the Chain of Meltdowns).
[Narrator]. 'We'll focus on what caused the chain of failures.'
(Toshihiro Nemoto, Investigative Reporter).
'The Fukushima accident lead to the shut-down of all the nation's reactors, but the Kansai Electric Power Company has re-started Reactors No 3 and 4 at it's Oi nuclear plant. The government has confirmed their safety but many citizens remain worried. They've held demonstrations against the move. They say last year's nuclear accident requires more investigation; how much really is known about the disaster ?'.

(Meltdown: Fukushima Nuclear Crisis. Behind the Scenes. (Broadcast Jan 2012))
'On March 11, 2011, the Fukushima Daiichi Plant was hit by an unexpectedly large tsunami. The waves knocked out the power supply which lead to the shutdown of the reactor cooling system. Our programme [of Jan 2012] casts a spotlight on Reactor No. 1. It pointed out the part... understanding an important cooling device played a decisive role in the crisis. Let's review the accident'.

[Table of times and events	R1	R2	R3
Mar 11, 14:46 Earthquake			
15:35 Tsunami			
	Loss of cooling system		
Mar 12, 01:09	Meltdown		
15:36	Hydrogen explosion		
Mar 13, 02:42			Loss of cooling system
10:45			Meltdown
Mar 14, 11:01			Hydrogen explosion
13:25		Loss of cooling system	
19:01		Meltdown	
Mar 15 after 06:00		Containment vessel broken ?	

[Sub-table for Reactor 1].
'The first hydrogen explosion occurred at the building housing Reactor No 1. It happened after the meltdown which took place about 10 hours after the earthquake. In this programme, we'll take a look at Reactors 2 and 3'.

[Sub-table for Reactors 2 and 3].
'The temperatures in these reactors were under control for a while after the tsunami. There was sufficient time to take action and the staff should have known what they needed to do.
[5:50]. So why could they not prevent the meltdowns and the release of huge amounts of radioactive substances ?
(Reactors 1-3 had different types of [Emergency Core] cooling devices).
To find the answer, we met often with TEPCO workers who tackled the crisis at the site.
[6:03]. We discovered that both the utility and government bodies continued to ignore a crucial problem related to nuclear safety. We'll first look at Reactor No 2. Unlike the buildings housing Reactors 1 and 3, this building didn't experience a hydrogen explosion. It looked quite normal. And yet Reactor 2 was in the worst condition of the three'.

(Japan Atomic Energy Agency, Tokai Village, Ibaraki Prefecture).
[Narrator]. 'We captured the first ever footage of evidence that illustrates how serious the problems at Reactor 2 were.
[6:42] Contaminated water that leaked from the reactor after the core meltdown is in these containers.
Reactor 2 is believed to have leaked the largest amount of radioactive substances. The contaminated water was taken from a building right next to the reactor.
(Primary Containment Vessel).
Inside the primary containment vessel which protects the reactor, extremely high radiation was detected. It was strong enough to kill a person after a few minutes of exposure.
(Main control room – label).
The main control room played a key part in dealing with the accident.
(Quake proof building (Emergency headquarters) – label).
The on-site emergency headquarters is located inside the quake-proof building. What was happening there ?
[7:51]. Managers who responded to the accident gave their accounts for the first time in front of the camera. They also feared Reactor 2 was in the worst shape'.
(Reactor 2 crisis response chief).
'Mmm. I thought that my heart was going to stop beating. I was really scared. We couldn't inject water. The water inside the reactor was leaking [boiling off]. If that continued, the reactor would start burning inside without any way to cool it. In the worst case scenario, soaring pressure would have wrecked the reactor; I don't want to think about it but eventually the containment vessel would have cracked [or ruptured]'.

[Narrator] 'Here's a graphic representation of what the on-site workers were afraid might be imminent. Even after a reactor stops operating, the nuclear fuel inside continues to emit massive amounts of heat. A loss of water to cool the fuel would result in a meltdown. The dissolved [molten] nuclear fuel would penetrate the bottom of the reactor and spread into the primary containment vessel. Should the containment vessel break, vast quantities of radioactive substances would spew out. Once that happened no-one would be able to come near to the reactor. The manager said Reactor No 2 came the closest to this worst case scenario'.

(Reactor 2 crisis response chief).
'If such an event really occurred, we wouldn't be able to do anything. It would have been like a living hell. I was thinking 'this could turn into another Chernobyl, if worst came to worst'.

[Narrator] 'How did the situation at Reactor No 2 become so dangerous ? Based on interviews with more than 300 people who responded to the crisis, we have created a detailed re-enactment of what was happening at the time.
(TEPCO video)
[9:58]. (March 14, 2011).
On March 14th, three days after the earthquake, a hydrogen explosion blew apart the building that housed Reactor No 3. The strong shock reached Reactor No 2 as well.
(Reactor 2. Main control room).
Darkness surrounded operators wearing masks and protective suits. Reactor No 2's cooling system was still operational at this point'.
('Check the cooling system')
('Will do').
[10:47]. ('Reactor water level: 3,400 above Top of Active Fuel'). ('Cooling seems to be working').
[Narrator]. 'But two and a half hours later, the cooling system would stop. To prepare for such an event, the operators had started taking steps to prevent a meltdown.
(Reactor).
Once the cooling system stops, the water level inside the reactor drops rapidly.
(Water inlet – label).
If the water is replenished through the water inlet, a meltdown can be avoided. But the pressure inside the reactor is extremely high. 70 atmospheric pressures. So the reactor needs to be decompressed [depressurised] to let the steam out first, before water can be injected.
(Decompress), (Inject water).
But how can that be achieved ?
(Reactor 2, Main control room).
In the main control room, the operators were preparing to decompress the reactor, using batteries gathered from cars within the plant's grounds'.
('Batteries connected. Ready to operate valves').
('Copy that').
('Open SR valve, A valve !').
('Understood. Opening SR and A valves').
(Safety Relief (SR) valve).
[Narrator] 'Safety relief valves or SR valves are used to release steam from a reactor when the cooling system breaks down. There are eight SR valves attached to the outside of the reactor.
(SR valves)
If the operators could open even one, that would lower the internal pressure right away and allow them to inject water'.
(SR valve) (Pipe from reactor).
This equipment simulates the operation of an SR valve. Open the valve, and steam gushes out. After about 20 minutes, the pressure is low enough for water to be injected'.

[13:37]. (Kashiwazaki-Kariwa Nuclear Power Plant).
[Narrator] 'SR valves are located inside the primary containment vessel that houses a reactor. We were able to record actual SR valves in a nuclear power plant that's currently offline. No-one is allowed inside a primary containment vessel while the reactor is running.
(SR Valves).
That means SR valves cannot be opened by hand. They need to be operated remotely from the main control room.
[14:19] 'Normally the operator turns a lever in the main control room. The light changes from green to red and an SR valve opens. But...'.
('SR valve not responding'). ('SR valve not responding').
('Isn't it open ?')
('How are the batteries ?')
(SR valve operation chief).
'I was told that the SR valves might not open. And I remember panicking, wondering why they wouldn't open. I felt a kind of big block of lead sitting in my stomach'.

(Masatoshi Fukura, Unit Superintendent Reactors 1-4). (Masao Yoshida, Fukushima Daiichi Plant Manager).
[Narrator]. 'A sense of crisis swept through the on-site staff, including the top executives.

(Tokyo Electric Power Company (TEPCO)).
Masatoshi Fukura lead the crisis management at Reactors 1 through 4. He too wondered why the SR valves wouldn't open. They'd been operable before'.
(Masatoshi Fukura, Unit Superintendent. Fukushima Daiichi Nuclear Power Plant, TEPCO).
'We were gripped by a sense of urgency. If we couldn't lower the pressure inside Reactor 2 and go to the next step, meaning if we couldn't cool the reactor, that would have triggered a horrific situation. Massive amounts of radioactive materials would have leaked outside. So I'm sure everyone was trying to think of a way to decompress Reactor 2 and inject water'.
[Narrator] 'Why couldn't the staff open the emergency SR valves ?
We worked with experts on reactors and nuclear plant accidents to find an explanation'.
[16:30]. (Hisashi Ninokata, Professor Emeritus, Tokyo Institute of Technology (Nuclear reactor physics)).
'Well I think that such a severe accident could have been avoided'.
(Hiroshi Miyano, Professor, Hosei University. (Former engineer at nuclear power plant manufacturer)).
'SR valves are key to preventing a core meltdown. Why didn't they open ? That's an important question'.
(SR valve component).
[Narrator] 'The experts focussed their attention on the SR valve structure'.
(SR valve). (Pipe from reactor). (Valve).
'The SR valve has another valve connected to it. This valve opens when electricity flows from a battery. Then nitrogen is released and pushes the SR valve up from below. This would have released steam from the reactor, greatly lowering the internal pressure. Where was the hidden problem with this mechanism ? Several investigations have been conducted into the accident at the Fukushima Daiichi nuclear power plant, but none of the results highlight the structure of the SR valves on Reactor 2'.

(National Diet's Independent Investigation Commission report).
[Narrator] 'It took time to prepare the batteries. That's according to a report by the National Diet's Independent Investigation Commission'.
(TEPCO's accident report) (Power supply)
'Meanwhile, TEPCO's report says the power supply was lost due to the tsunami and says nothing about why the SR valves didn't work.

'What prevented the SR valves from working ?
(Masahiro Osakabe, Professor, Tokyo University of Marine Science and Technology (thermo-fluid engineering))
'A specialist in the field of thermo-fluid engineering pointed out an unexpected cause.'.
[Osakabe]. 'If the pressure soared in the primary containment vessel, the pressure within the SR valve wouldn't be sufficient to force the valve open. It can only open if there were a certain level of difference between the air pressure in the valve and the pressure in the containment vessel'.

[18:51]. [Narrator]. 'Once the cooling system stops, the temperature inside immediately starts to rise.
(Reactor). (Primary containment vessel).
This increases the pressure in the primary containment vessel and keeps the SR valves from opening. If the pressure surges within the containment vessel, the pressure inside the SR valve also goes up and presses down on the valve. Unless the force of the nitrogen within the valve increases, the pressure from above will keep the valve from opening.
(Diagram of meltdown).
If the SR valve remains closed, there's no way to prevent a meltdown and the situation will deteriorate as the meltdown progresses. That's because the temperature inside the reactor will keep surging and the pressure within the primary containment vessel will also continue to rise. The safety mechanism is supposed to stop a meltdown and yet it becomes less effective as the meltdown worsens.
The experts said such an ironic outcome hadn't occurred to them prior to the accident'.
(Hisashi Ninokata, Professor Emeritus, Tokyo Institute of Technology (Nuclear reactor physics)).
'I don't think the operators had ever expected the pressure inside the primary containment vessel to reach 6 or 7 atmospheric pressures. And that would have prevented the SR valves from opening. There might be other causes, but I am sure that that was one of them'.
(Hiroshi Miyano, Professor, Hosei University. (Former engineer at nuclear power plant manufacturer)).
'All SR valves undergo testing of course, but not under such extreme conditions. It's difficult to test and make sure the valves function as designed at all times because you can't cover all possible scenarios in a testing environment'.
[This is the critical problem of nuclear power. It is logically impossible to anticipate all possible failure modes].
'The engineers probably didn't realise there was a problem'.

(Quake-proof building).
[Narrator]. 'After the accident, TEPCO workers are said to have made desperate attempts to open the SR valves, but apparently no-one mentioned the possible effects of high pressure inside the primary containment vessel'.
(SR Valve operation chief).
'To tell you the truth, I don't recall having any discussions at the time about whether high pressure within the primary containment vessel was keeping the SR valves from ..opening. There were lots of SR valves, so we were busy checking every single one of them'.
(Reactor 2, Main control room).
('Panel 9-45')
('Let's link to the solenoid valve')
[Narrator] 'The operators in the main control room were trying the eight SR valves one by one. They couldn't understand why they wouldn't open'.
('SR valve ready. Batteries connected directly to solenoid')
('Copy that. Confirm reactor pressure is down')
('Understood').
('Reactor pressure.... It's not down'). ('Pressure's still rising').
('Why isn't it coming down ?'!')

[22:36]. [Narrator]. 'The expert's simulation for reactor No 2 suggests that melted nuclear fuel penetrated the bottom of the reactor at 8:15 pm on March 14th. The massive heat raised the pressure inside the primary containment vessel. Destruction of the vessel was becoming increasingly likely. It was the last defence against radiation leaks. It's loss would have much more dire consequences than a hydrogen explosion in the reactor building'.
(Reactor 2).
'At reactor No 2, a meltdown was in progress. The operators were about to execute a last resort process called a “vent”.
(Reactor 2, Main control room).
It was the only way to protect the primary containment vessel and prevent a massive release of radioactive substances'.
('Venting wetwell (primary containment vessel)). ('I'll open the AO valve').
('Pressure's not down').
('Is the vent working ?')
('Air pressure seems low')
('Reactor 2, Main control room, The vent's not working').

(Primary containment vessel).
[Narrator]. 'A “vent” is an emergency procedure for lowering the pressure within the primary containment vessel. When a meltdown occurs, pressure surges in the containment vessel and a vast amount of radioactive substances pile up inside. To prevent the built-up pressure from destroying the containment vessel, a “vent” may be performed to release at least some of the internal gas from the reactor building'.
(Vent at Reactor 1. March 12, 2011).
'Even though explosions blew up the buildings housing Reactors 1 and 3, the “vent” probably kept their primary containment vessels from being destroyed'.

(Quake-proof building).
'But for some reason, the “vent” wouldn't work for Reactor No 2'.
[25:05] ('Still no news of the vent working').
('How's the primary containment vessel ?')
('Surging. Now 700 kilopascals') ('Radiation is also up in the containment vessel'). ('Fission products are piling up').
('Hurry up with the vent').
('OK').
[Narrator]. 'To perform the vent, two valves had to be opened. One of them had a handle [hand-wheel]. During the crisis, the operators were able to open it manually right away, without electricity. The problem was with the other valve. It didn't have a handle. It had to be opened remotely, like the SR valves. The second valve used air. Air had to be pushed inside to turn the gears. These actions should have released the gas from the primary containment vessel. But why didn't the vent work ?
(Compressor). (Air tank).
The on-site staff suspected that not enough air was being injected. The air came from the tank next to the building housing the containment vessel. The operators normally used a compressor to send air into the valve. But they couldn't work the compressor. The power supply had been wiped out by the tsunami. So they decided to try a different approach. The plan was to use a portable compressor to send air into the valve.
('Connect it').
('Compressor connected')

('Copy that').
This should have opened up the valve to release the pressure inside the containment vessel.
(Reactor 2, Main control room).
But for some reason, the pressure didn't drop'.
('Drywell pressure is 740 kiloPascals. That's high').
('Radiation's up, too... 29 sieverts') [micro-Sieverts/hour]
('We still can't vent Reactor 2') ('The radiation keeps rising').

[Narrator] 'Venting was the last resort, and it was failing. The unimaginable was happening. [It's the physics]. [28:10]. The worst case scenario began to loom large in the minds of the responders'.
(Reactor 2 crisis response chief).
'Part of me was extremely worried. I thought that the situation could end up ruining the whole country. And of course, I realised we might not be able to leave the site alive either'. [This is the consequence of a worst case nuclear disaster].
[Narrator]. 'Why wouldn't the valve open, despite efforts to pump air inside ? NHK obtained this footage of ductwork [pipework] in Reactor No 5. It's just like the system used to supply valves in Reactor No 2.
(Pipe marked 50A-I A-8R/B)
The 50 mm diameter pipes extend more than 70 meters. Cracks or gaps in the piping could prevent air from reaching the valve.
(Footage of the plant shaking during the earthquake).
A magnitude 9.0 quake shook these thin long pipes.
(Plot of 'Quake felt at Reactor 2', showing accelerations of up to about +/- 200 g and a peak of nearly – 600 g.).
'Quake intensity recorded at Reactor No 2 was 25 per cent greater than it had been designed to withstand.
(Diagram of containment, with labels Class S, Class B, Class C).
Government regulations establish quake resistance standards for nuclear plant facilities. The containment and most of the other core components of the reactor are built to Class S standards – the most stringent. But the standards dropped farther away from the reactor. The piping in question was rated Class C, the lowest level.

Naotaka Takamatsu analyses how earthquakes affect nuclear power stations. The leading authority in the field agreed to sit down with us for the first time after Fukushima.
(Naotaka Takamatsu. Deputy Director-General, Seismic Safety Division, Japan Nuclear Energy Safety Organization).
'Given the extreme force of the quake, I can't rule out the possibility that it damaged some of the piping. That might have caused air to leak out disabling the vent as a result. Therefore I find it extremely important to thoroughly investigate that possibility'.
[Narator]. 'TEPCO's investigators said in their report that few facilities were found to have been damaged by the quake. That includes those built to lower standards of quake resistance.

(Masatoshi Fukura, Unit Superintendent. Fukushima Daiichi Nuclear Power Plant, TEPCO).
[31:58] [Narrator]. 'Was there really no impact on the pipes that were so critical for venting the reactor ?
[Fukura] 'For instance, was there any leakage between the source of the air and the valve ? I doubt if they've checked everything on that level. In other words, no-one can tell why venting failed or if the piping was damaged by the quake until they've looked at the actual material. So that's one of the things I think will be done expeditiously if we are to continue to operate nuclear plants.
(Diagram of primary containment vessel).
(Plot of 'Changes in drywell pressure at Reactor 2'). (Designed pressure 0.49 Mpa).
[Narrator]. 'While responders were struggling to vent the reactor, the pressure inside the drywell rose far above permitted levels by the night of March 14th. News of the tense situation reached the Prime Minister's Office in Tokyo.
(Prime Minister's Office, Early Morning, March 15th, 2011).
[Prime Minister]. 'We will overcome this crisis at all costs'.
[Narrator] 'At this stage, then Prime Minister Naoto Kan went to TEPCO headquarters to speak with the management'.

(Reactor 2, Main control room).
[Narrator] 'At the main control room of Reactor No 2, all the workers could do was to repeat their fruitless efforts to release the pressure in the reactor'.
('Still can't vent Reactor 2')
('We have to somehow')
('It's still high...740 to 750 kilopascals')
[Narrator]. 'Alarming drywell pressure readings rang out in the onsite headquarters. But there was no good news'.
(Reactor 2 crisis response chief).
'As I was hearing the readings, I felt myself plunging into total despair. After all, listening to the reports was all I could do, even though I knew everyone was working as hard as they could'.

(Picture of plant).
[Narrator]. 'Then at 6 am on March 15th..'
(Explosion).
('Check the drywell and suppression chamber pressures')
('Yes, sir')
('What are they ?')
('Suppression chamber pressure ?')
('Zero').
[Narrator]. 'The pressure was zero.
(Graphic of drywell and suppression chamber, labelled 'Model', showing leak).
Front line workers thought part of the primary containment had been destroyed, releasing a massive amount of radioactive material.
[35:53] ('This is Reactor 2. We heard a loud bang') ('The suppression chamber pressure is now...... zero').

(Reactor 2 crisis response chief).
'If the containment vessel had really been destroyed, rather than just experiencing a minor leak, that could have meant evacuating everyone. It could have been fatal for those of us on the front lines. And that's what crossed my mind'.

(Picture of outside of plant).
[Narrator] 'What had happened to the containment vessel ? More than a year later, no-one seems to know'.

(Filmed at 10 AM, March 15, 2011)
'But an enormous amount of radioactive fallout was likely released after 6 am on March 15th.
(Highlight of smoke release).
This [still] photo offers evidence. Of all the radioactive releases following the Fukushima crisis, this one caused the greatest damage to residents'.

(Reactor 2 crisis response chief).
'The memory will stay with me for the rest of my life. But more than a year it still haunts me. I even have nightmares. I think one question will be stuck in my head for the rest of my life. How can the events at the nuclear plant be turned into something we can learn from in the future ?'.

(Yoshihiro Nemoto, Investigative Reporter. Shown in front of picture of pipework)
'As you've seen, pipes that were not built to withstand severe quakes might have cracked, leading to the breakdown of key safety equipment'.

(Table of Events for Reactors 1, 2, 3).
'The Diet Investigation Commission has pointed out that the earthquake may have played a role, in addition to the malfunctioning SR valves we showed earlier. Problems related to the most basic issues of nuclear safety remain unexamined'.

(Sub-table of Events for Reactor 3).
Next we look at Reactor No 3, which faced a crisis before Reactor No 2. Operators failed to prevent a meltdown here too, even though time was on their side. In the background was an issue that went beyond the grounds of the plant'.

(Picture of outside of plant).
[38:44]. [Narrator]. 'After the accident to Reactor No 1, Reactor No 3 experienced a core meltdown and hydrogen explosion. Operators had the time and the knowhow to prevent the crisis, but failed to do so'.
(Reactor 3)
'Why ? As it turned out, there was a hidden pitfall'.

(Reactor 3, Main control room, March 13, 2011).
'This was Reactor No 3's main control room 32 hours before the hydrogen explosion. Operators were continuing efforts to cool down the reactor with the few batteries that had survived the tsunami. A day and half had already passed since the tsunami ploughed through the plant. It was just a matter of time before they would run out of batteries'.

(Footage of operating switches without effect)
('I can't confirm the SR valve is open')
('Power may be too low')
('We can't open the SR valve at Reactor 3. We can't lower the pressure')
('We may run out of batteries')

(Map of location of Fukushima Daiichi Nuclear Power Plant)
[Narrator]. 'At the onset of the crisis, TEPCO had arranged for batteries to be delivered to the Fukushima Daiichi plant.
(Shot of twin-rotor helicopter and of 2-volt battery).
The Self-Defense Forces delivered 2-volt batteries which are often used at power plants.
(12-volt battery)
But operators needed 12-volt batteries to open the SR valves. The batteries are highly portable and weigh as little as 10 kilograms. Ten of them provide enough power to open an SR valve.
[41:07] (Quake-proof building)
At the quake-proof building, workers were procuring emergency supplies.
('We need 120 volts to open the SR valve') ('Otherwise we cannot pour water into the reactor')
('That means a core meltdown') ('No 12-volts have been delivered')
('We have to take batteries from our own cars')
('If you're free, bring us the battery from your car')
('This is headquarters. We'll get them to you as soon as possible')

[Narrator]. 'Why didn't the operators get the batteries they asked for ? During the early hours of the crisis, TEPCO found it hard to keep up with requests for emergency supplies. A senior official in charge of procurement at the time says his team wasn't able to prioritise the request for 12-volt batteries.
(Atsufumi Yoshizawa, Senior official in charge of procurement (then))
'The people responding to the crisis needed all kinds of things. We were trying to juggle all of the requests at the same time. Trying to get them delivered as quickly as we could. We didn't have time to prioritise. We just tried to grab whatever was on the list regardless of quality. I believe we were in a situation where screening each request according to priority was very difficult'.

[42:55] (Map of Fukushima Daiichi plant with ring and distribution point of 20 km radius).
[Narrator]. 'As a result, the distribution station received nothing but 2-volt batteries during the crisis. Most of them remained on the shelf. The chaotic approach to providing essential materials deepened the disaster.

(Footage of outside of plant).
At Fukushima Daiichi, workers were still without the batteries they needed to prevent a meltdown. Rising radiation levels compounded the problem'.

(Plan view of plant, with spot highlighting the main gate)
(Plot of 'Radiation levels near the main gate'). [Note logarithmic scale].
'This shows radiation levels near the main gate of the plant. On March 13th, the number rose to 281micro-sieverts per hour. At that rate, the annual exposure limit would be reached in just four hours'.
(Reactor 3, Main control room).
Without the batteries they desperately needed, the operators were driven into a corner'.
('I can see the water level') ('Down 2,000 from Top of Active Fuel') [So the top 2 meters of nuclear fuel lacks cooling]
('Reactor 3 water level is down 2,000 from Top of Active Fuel')
('Can't open the SR valve') ('Any batteries yet ?')

(Map showing Fukushima Daiichi, with 20 km to Distribution point – later with 'Stock base (Onahama)).
[Narrator] 'TEPCO had procured 12-volt batteries. But as of the night of March 13th, they remained at a stock base 55 kilometers from the crippled plant. There were more than one thousand of them.
(Montage of photos).
These are photos of supplies at the base. Small pumps and generators were also stranded there. No mechanism existed to transport goods to the contaminated plant.
(Footage of outside of plant)
The workers at the plant felt that, without the proper support, preventing a meltdown was impossible'.
(TEPCO employee who responded to the crisis).
'Things that we needed the most didn't come at all. Really, what would you expect us to do under the circumstances ? I know I shouldn't speak like this, but that's how we felt. People may say the explosion could have been avoided if we'd had this or that. I'm afraid there's no end to such hypothetical arguments'.

[45:56] (Reactor 3, Main control room)
[Narrator]. 'Japan lacked a system to deliver necessities to nuclear plants contaminated with radiation. Eventually workers at Reactor No 3 had to resort to using batteries from their own cars. Six hours had already passed since attempts to cool the reactor failed'.
('Connecting batteries to the SR valve control circuit')
(Animation showing meltdown)
But our simulation showed nuclear fuel had already been damaged, releasing hydrogen into the reactor building'.

(Hydrogen explosion at Reactor 3. 11:01 AM, March 14).
(Footage of re-enactment)
(TEPCO video of damaged building housing Reactor 3)
[Narrator]. 'During the Fukushima crisis, three reactors melted down in succession. The radioactive material they released have contaminated the soil. More than 160 thousand residents are still unable to return home'.

(Masatoshi Fukura, Unit Superintendent. Fukushima Daiichi Nuclear Power Plant, TEPCO).
'Again I believe those operators responding to the crisis on the shop floor, well they did their best. Yet, given the consequences presented, mmm, I'd say 'we failed to meet the challenge'.

(Yoshihiro Nemoto, Investigative Reporter)
'The nuclear crisis upended many lives and spread radioactivity over a wide area. To what degree can it's consequences be understood ? Some of the issues we've raised in this programme, such as problems with the SR valve and the impact of the earthquake on critical ductwork [pipework] came to light only after the accident. Earlier this year, we said that the other nuclear reactor shouldn't be restarted until we thoroughly understand what caused the Fukushima crisis. But some of those reactors are going back on line. The government insists that stress tests and emergency safety measures ensure a Fukushima-like accident will not happen again.

(Shot of model of Fukushima plant)
'But is that really the case ? Even if a plant is well-designed, it might not work as expected. What would they do then ? Specific safety plans have yet to be verified, including off-site support systems. Meanwhile at the disaster site, work has just begun to decommission the reactors; a process that could take as long as forty years. What lessons are to be learned from Fukushima ? This important question remains unanswered'.

[49:44] (End credits).