How Accurate Are The Instruments in Nuclear Reactors?

By Maggie Gundersen, Lucas W Hixson, and David Lochbaum
Global Research, October 22, 2013
Fairewinds Associates and GRTV 17 October 2013

Region: Asia
Theme: Environment, Oil and Energy

Accurately measuring the reactor water level in a nuclear power plant is critical to safe operation, yet nuclear power reactor water monitoring systems do not work correctly. What would happen today if your car's speedometer read 60 miles per hour, but in actuality, you might be driving at 40-mph or even 95-mph?

Listen to today's Fairewinds Energy Education podcast as Dave Lochbaum from the Union of Concerned Scientists and researcher Lucas Hixson discuss the dangerous dilemma reactor operators face when a reactor has an emergency shutdown and operators simply do not know if the reactor has enough water to keep it cool!

Transcript:

MG: Hi this is Maggie Gundersen for Fairewinds Energy Education. Today we're doing a special show about reactor water level monitoring. We have as our guests nuclear researcher Lucas Hixson and Dave Lochbaum, nuclear expert with the Union of Concerned Scientists. This is not one of our typical podcasts in that this is a very technical podcast, but it's for you geeks out there. A lot of people have written in to us and asked for this kind of material, and even if you're a layperson I think that you will really, really find this interesting and it'll give you insight into how difficult it is to operate a nuclear power reactor. Thank you for joining us.

LH: Good afternoon. I'm Lucas Hixson and I'm here today with Dave Lochbaum with the Union of Concerned Scientists, and we're going to be speaking about what is called the Reactor Water Level Monitoring System at nuclear power plants. Water is used in the nuclear reactor as a critical neutron moderator and coolant. Water levels in a nuclear reactor are not monitored directly, but rather through an indirect monitoring system, which incorporates a reserve tank which is termed a *reference leg*. There have been some reported flaws with this cooling system throughout the years, some of the most notable being brought forth by Paul Blanche in the early 1990's. Dave, can you explain to us some of the nature of his findings?

DL: Yes. Paul found some problems with the level instrumentation used in boiling water reactors like Fukushima in Japan and Pilgrim and Browns Ferry here in the United States. As you mentioned, in that type of reactor, the water boils right in the reactor vessel. It's difficult to measure the level of water that's vigorously boiling. If you imagine a pot of boiling water on the stove, you see all that froth level at the top, what *is* the level of water in the pot? So what boiling water reactors do is use the reference leg, which is just a non-boiling column of water, and compare the pressure or the weight of that water to the weight of water in the reactor. And we can judge the density of the water in the reactor vessel easier than we can determine its actual height. And we can use that differential pressure between what the weight of the water in the reactor is versus the weight of the water in that reference column to determine what the level of the water in the reactor vessel is. If you look at a bottle of soda pop and you shake it up and then crack the top, the water level – the beverage level jumps from a nice low level to spewing out the open top. Because the non-condensable gases inside that soda have become freed by the agitation. Likewise, what Paul noted was that if the pressure of a reactor vessel were suddenly to drop, as it could happen during an accident, the non-condensable gases inside the water can cause the water in the reference column to all of a sudden change dramatically as bubbles come out of that water due to the pressure drop, which is similar to cracking a soda pop. Its pressure drops and the bubbles form. We hadn't accounted for that in the water level instrumentation. As those bubbles formed under that situation, the indications of level to the operator could become vastly wrong – several feet, dozens of feet wrong. And the reactor core is only 12 feet tall and if the level instrumentation is off by 20 feet, you've got a big problem.

LH: Is there any other method for operators to determine the water level if the reactor water level monitoring system is not providing accurate data?

DL: The operators are provided about five sets of water level instrumentation for boiling water reactors. They're calibrated at hot conditions, high pressure, high temperature, as well as cold conditions where the reactor is shut down and the reactor vessel's head is off, the water is less than 212 degrees. The problem is that during an accident, you go from high temperature, high pressure to high temperature, low pressure as this pipe breaks and water flows out. The operators must choose amongst these five sets of instrumentation to figure out which one is most accurately monitoring the conditions at that moment; and that indication will shift from instrument to instrument, and it's the operator's guess as to which one's providing the most accurate indication. And when you have 100 tons of reactor core to deal with, when you start playing guessing games, a wrong guess comes at a high cost.

LH: If I remember correctly, the NRC had allowed for a 30-inch discrepancy in that reference leg measurement. And sometimes those measurements could be off by more than 20 or 25 feet. Is that correct?

DL: For example, at Brown's Ferry, we had three level instruments, all with reference legs, and they sometimes would be indicating a foot or more difference between one and the other, and they're all supposed to be monitoring the same thing.

LH: So now that we've discussed the possibilities of operators not being able to accurately assess the water levels in a nuclear reactor due to non-condensable gases building up in the reference leg, I would like to pose another plausible system flaw to you. There has been a common observed phenomenon at nuclear accidents, which I feel may not receive enough attention. Reactor operators have been repeatedly put in situations where they have been unable to trust the very equipment that they rely upon to tell them what is occurring in the nuclear reactor, and have reacted either correctly or incorrectly based on that untrustworthy data. And later, these same reactor operators have been blamed for those accidents due to some form of operator failure. Dave, as an example for this, could you share with us some of the instrumentation difficulties that operators experienced at

Three Mile Island?

DL: Certainly. In March of 1979, the Three Mile Island reactor was operating at about 97 percent power when it experienced an unplanned shutdown – automatic shutdown of the reactor that brought it to a subcritical shutdown condition within seconds. That had happened 13 times in the previous year that the reactor had operated, but the 13th time – this time – proved to be very unlucky. Things were nice and balanced where the plant was operating at 97 percent power, but also in the reactor shutdown, there's a big transient as an effort to try to rebalance the power being produced by the reactor and the power being carried away by the support systems. During the transient there was a valve that opened at the reactor vessel to allow pressure to be relieved by discharging fluid through that valve into a tank. This time – and that's normal – that's the design and the plant handled it – a few seconds of transient while the balance is being restored. But in this situation, that valve stuck open. It was supposed to reclose when the pressure dropped back down, but due to mechanical failure, the valve stayed open. The operators were instructed, trained – the procedures, all the guidance had been geared towards preventing the tank on which that valve sat on top of, from ever becoming filled with water. It was partially filled with water to accommodate the swelling and contraction of water as the reactor heated up and cooled down. It was kind of like the overflow tank in a car engine. Because that valve stuck open, the water level inside that tank was indicating to be out of the top, completely filled. That was not the actual water level, but because the valve was open, kind of like the soda pop bottle earlier, the water level in that tank was falsely out the top, when in fact it was created by a bunch of bubbles being formed in that water by the pressure of the open valve dropping the pressure, kind of like removing the top or cracking the top on the soda bottle. The operators reacted to that false indication by turning off the pumps that had started to provide makeup water to cool the reactor. They turned those pumps off because they falsely thought the reactor had too much water when just the opposite was happening. Over the next two hours, they succeeded in draining more water out of the reactor vessel because they were trying to get the water level in that tank back normal. The false indication continued for nearly two hours to cause them to drain the water out of the reactor vessel until the reactor core was partially uncovered and it melted down. It overheated and melted down. But those operators were doing exactly what they were trained to do; exactly what their procedures told them to do. But they relied on a false indication and were led down a very bad road.

LH: Now were there any indications prior to Three Mile Island that a valve would fail in an open configuration like that?

DL: Shortly over a year earlier, the Davis Bessie plant in Ohio, which was a twin sister to Three Mile Island, experienced a very similar event. They had a shutdown. But at that time, the reactor was operating at about 90 percent power. That valve also opened to handle the pressure transient during a few seconds while things were rebalanced. It also stuck open. But the operators in that case noticed the valve was stuck open and they closed another valve in that same pipe which effectively stopped the flow through there. The pressure inside the tank dropped back to its real level instead of the falsely indicated high, and they came through that no problem. One of the problems was that event was even though it occurred and was successfully dealt with, the owner, the reactor vendor and the Nuclear Regulatory Commission didn't share that with anybody else so that the operators at Three Mile Island and elsewhere weren't forewarned about that potential situation. So when they stumbled upon it blindly, they misdiagnosed it with disaster as a result.

LH: And to me, that has connotations of the types of failures that were experienced at Chernobyl as well, where operators were responding in ways that they thought were appropriate, but due to the other configurations on site, were actually not following the procedures that would help them to mitigate the accident.

DL: It's a common theme. Again and again, we trap the operators. We give them a set of instructions that are intended to handle a wide range of scenarios, but nature follows the same script they're being led down wrong paths. It happened, as you said, at Chernobyl, it happened at Three Mile Island. To a certain extent it happened at Fukushima. We don't seem to learn the right lessons from those disasters.

LH: My concerns with this obviously being that with the reactor operators, rather than setting them up for success, we're putting them in a situation where they can inevitably not do the correct things and are set up for failure. According to Tokyo Electric, the operator of the crippled Fukushima Daiichi power plant, they, too, experienced issues with the reactor water level monitoring system at its reactors during their response to the March 11th earthquake and tsunami. Specifically at unit 1, after the loss of power, operators were scrambling to find backup power supplies with which to power the control room monitoring systems which would allow them to determine what was happening inside of the nuclear reactor. When they temporarily restored power to the reactor water level monitoring system using backup batteries, the gauges told operators the water levels were above the top of active fuel; but in fact, in further analysis, we found that at that time, the whole core was exposed and had been exposed for more than 90 minutes by the time that backup power was restored. Now according to TEPCO, the temperatures in the core had reached the point where fuel damage had started to occur, and had also become so hot that they evaporated the water in that reference leg. Due to the pressure in the reactor pressure vessel, false readings were registered on the gauges when power was temporarily restored. Now to me, this means that the reactor water level monitoring system is capable of providing reliable data for operators during normal operations. But if there's just one bad day, the system is also capable of failing after the point of core damage. Do you have any comments on this?

DL: I would agree to an extent. The water level instrumentation in other systems at the plant are designed for normal operations and postulated accidents. But when accidents don't follow the scripts that we've written, the indications the operators get or the guidance that they're given can be more harmful than helpful. And that's really not the situation we should put them in.

LH: Now at Fukushima Daiichi, we also apparently have observed now that if reactor operators in the future find themselves in a situation where they postulate fuel damage could have occurred, that the temperatures in the reactor itself could have already potentially reached such levels that they evaporate the water in the reference leg, and then the public would be in a position that they're forced to trust the words of the industry, which would be unable to trust its own data. Is this correct?

DL: Unfortunately, yeah. The way it is now and the way it is for the foreseeable future is the best indication we have whether the water level indications are accurate or not is whether you see a radioactive cloud coming from the plant that would suggest that the indications are false. We need a better indication than a radioactive cloud telling us whether we do or do not know the water level. That's too big a price tag to pay for knowing that we're wrong.

LH: Dave, are these same reactor water level monitors used at both PWR and BWR styled reactors?

DL: They're used on boiling water reactors. The pressurized water reactors use a similar but slightly different system. On pressurized water reactors, there's actually not even water level instrumentation for the reactor vessel because, per our accident scripts, we don't ever drain water out of the primary system. The water level instrumentation is on the steam generators for the pressurized water reactors, which is a secondary loop of water outside the reactor vessel. The steam generators use a system similar to that used in boiling water reactors to monitor the water level inside the steam generators. On pressurized water reactors, except when they're shut down, there's really not a system used to monitor the water level inside the reactor vessel.

LH: Are these issues being addressed? And how could they be addressed? And who should be working on the answers to these problems?

DL: We seem to be always fighting yesterday's battle, which needs to be done. But we need to broaden the scope to look at key parameters that need to be monitored by operators and whether those parameters will be accurate or not during various accident and severe accident scenarios that they may face. We can't put operators in the position of having to guess what's going on because they may guess right. But if they guess wrong, a lot of people pay a hard price. So I think the federal government, the national labs and the industry should be looking at every key parameter, whether it's pressure, water level, temperature, hydrogen concentration or whatever is necessary to be controlled during an accident, we need to insure that the operators get reliable information on those parameters so they can take the right actions at the right times. For example, the poor operators at Fukushima who struggled to repower instrumentation only to be given false indications – they shouldn't have been in those shoes in the first place, but if we do that again to anybody, that's shame on us.

LH: The public obviously has a duty to keep themselves informed and to insure that regulators are doing their jobs to address these issues. But how can reactor operators also help the Regulatory Commission as well as the nuclear industry with addressing these problems?

DL: The plant operators – the owners of nuclear power plants, have a multi-billion dollar asset that they don't want to see lost. So they have every reason in the world to make sure that the operators of those plants are given reliable information. They should not just fix yesterday's problems. They should look at the instrumentation issue more broadly, to look at how to make things better. For example, many plants are replacing old analog equipment with digital equipment because you just can't find some of those spare parts any more. As you go to digital equipment, as you replace some of this instrumentation, make it better; make it more reliable. Make it so that it can handle a wider range of scenarios other than the very narrow scripts that we write for accidents. If we don't do that, we're just relying on luck to prevent the next Fukushima or Chernobyl or Three Mile Island. And the fact that that list keeps growing shows that luck makes a lousy barrier.

LH: When we're speaking about upgrading the analog instruments to digital instruments, I'm also reminded of the event at North Ana in 2012, where they had updated some of the earthquake seismic instruments with digital instruments, but they were not capable of recording the actual earth shaking on site. They were forced to rely instead on the scratch plates. What kind of testing is done with these digital instruments to ensure that they're going to be able to accurately report data in these situations outside of normal operations?

DL: Well, the makers of the instrumentation will say that they do really good testing, but the users of that equipment, are showing that those marketing claims are falling short of reality. The Browns Ferry nuclear plant also had a problem with digital equipment in that the internet traffic was so high that it interfered with controls of two pumps, sending cooling water through the reactor core causing them to trip offline. So we obviously have some more homework to do to make sure the digital equipment is reliable just for day-to-day operations, let alone handling accident situations.

LH: In response to the Fukushima Daiichi accident, the Nuclear Regulator Commission has expanded some safety instrumentations at nuclear power plants also specifically related to the spent fuel pools. Can you share a little bit with us about that?

DL: One of the problems at Fukushima was that there were seven spent fuel pools. During the accident, the water level and the temperature of that water in the spent fuel pools was unknown to the operators in the control room because they had no instrumentation installed to provide that even if power had been available. So the operators were distracted by sending somebody physically up to look at what the water level was or try to figure out what the temperature was. To avoid that situation here at U.S. plants, the Nuclear Regulatory Commission in March of 2012 ordered plant owners to install reliable water level instrumentation. Sounds good. But the order ordering plant owners to install instrumentation monitored the level down to a foot above where the spent fuel assemblies are stored in the pools so if there is a problem and the water level does drop, the operators may not know that the level is now below the top of the fuel and fuel damage may be imminent. All they know is it's down to within a foot, no lower. There was an opportunity there to measure the water level of the entire pool, not just part of it. Again, we're assuming that accidents will follow our scripts, we'll be successful getting water back in before it drops that low and we'll be setting the operators up for a trap if the water level drops below that. So again, we're replicating the mistakes of yesterday, not learning the solutions from those disasters.

LH: Thank you so much, Dave. Once again, I'm Lucas Hixson and we're speaking with Dave Lochbaum with the Union of Concerned Scientists. Once again, I'd like to thank you for joining us for this conversation.

DL: Thank you, Lucas, and thanks the work you're doing in putting a light on these issues. That's one of the best ways to try to get some of these problems off the table and into the rearview mirror behind us.

NWJ: Thanks for tuning in to the Fairewinds Energy Education podcast. If you've come to depend on Fairewinds for your source for unbiased nuclear news, please consider supporting our work with a contribution so that we can continue to produce high quality energy education programs like this one.

–

Tune into Global Research TV for the latest video updates from Global Research!

The original source of this article is Fairewinds Associates and GRTV

Comment on Global Research Articles on our Facebook page

Become a Member of Global Research

Articles by: Maggie Gundersen, Lucas W Hixson, and David Lochbaum
http://fairewinds.org/