Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions
issue brief

Pressurized Water Reactor Containment Sump Failure

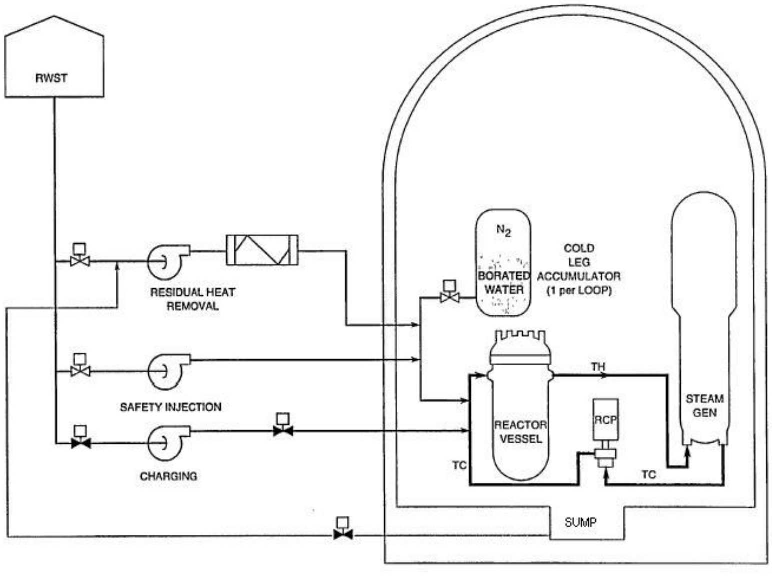
According to government reports, the odds that one of the nation's nuclear power reactors will have a serious accident is about 100 times higher than necessary. This clear and present danger is virtually being ignored by the federal agency empowered to protect the public. Instead, this agency focuses its attention on improving the financial performance of the nuclear industry. The danger is failure of the containment sump during an accident at a nuclear plant with a pressurized water reactor. The cavalier agency is the Nuclear Regulatory Commission. The time is now to poke and prod the Nuclear Regulatory Commission into setting aside the industry's business for as long as it takes to eliminate this undue threat to public health and safety.

What is the pressurized water reactor containment sump problem?

Sixty-nine of the nation's 103 operating nuclear power units are pressurized water reactors (PWRs). The PWR gets its name from the fact that water flowing through the nuclear core inside the reactor vessel is maintained under high pressure (approximately 2,200 pounds per square inch) to prevent it from boiling even though it gets heated to over 500°F. The hot water flows from the reactor vessel to two or more steam generators inside the containment building. The hot water flows through thin metal tubes inside the steam generators. Lower pressure water on the outside of the tubes absorbs heat passing through the tube walls and boils to produce the steam that spins a turbine/generator to make electricity. The water coming out of the steam generator tubes – about 20°F cooler – is pumped back to the reactor vessel to be reused.

If the reactor vessel gets a hole in it, or the piping between the reactor vessel and steam generators breaks, or a relief valve opens, the high pressure forces water out through the opening very rapidly. This is called a loss of coolant accident (LOCA), because the water removes heat produced by the nuclear fuel, thus cooling it. If this heat is not removed, the nuclear fuel will be damaged from overheating.

When plant sensors detect a LOCA, such as by the rapid drop in pressure inside the reactor vessel, safety features automatically begin to supply makeup water. For example, the charging and safety injection pumps will automatically supply makeup water taken from the refueling water storage tank (RWST).



Even if the RWST were infinitely large or if a backup to the RWST was available, at some point the operators must switchover the source of makeup water from the RWST to the containment sump. Recall that the makeup water is needed to compensate for the water pouring out through a broken pipe or open relief valve. This spilled water drains to the basement of the containment where the sump is located. If only outside water is used, the containment would fill up with water, submerging electrical equipment inside containment that must operate and challenging the

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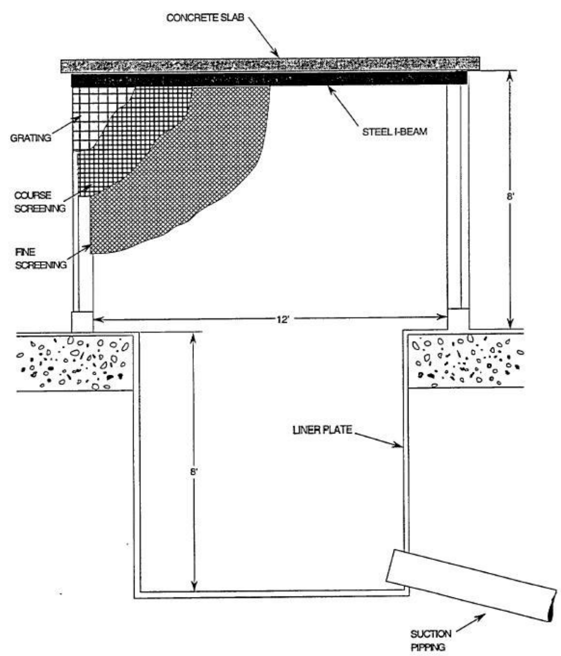
structural integrity of the containment by the sheer weight of the rising water. So, operators close the valves from the RWST and open the valves from the sump so that the pumps recycle the water inside containment.



What is the containment sump?

The containment sump is more than an open pit as illustrated in the simplified diagram. The sump is covered by screens to prevent debris from fouling the emergency pumps. The configuration of the containment sumps and their protective screens vary from reactor to reactor, but the figure shows a typical arrangement. The mesh-size of the fine screening determines the largest debris particle entering the containment sump and therefore the safety pumps when they stop getting their water from the RWST.

Where does the debris come from?

The high-pressure water escaping through a broken pipe essentially scours thermal insulation and protective coatings (i.e., paint) off adjacent piping, equipment and structures. After creating debris, the water transports it to the containment sump.

Screen of 1/8-in. Mesh Opening Obstructed by Cal-Sil (Small Yellow Lumps) and Fiberglass (Uniform Translucent Mat). Close Inspection Reveals Very Small to Microscopic Cal-Sil Granules Imbedded in a Complex Fiber Mat. The Broken Bed to the Right of the Photo Was Damaged During Screen Removal. Nominal Fiber Thickness is 1/10-in.

Typical Nukon fiberglass insulation debris used in transport testing.

How much of the debris generated during a LOCA has to be transported to the containment sump to block its screens?

According to an NRC report, it takes less than 10 percent of the fibrous material generated during a small-break LOCA to clog the containment sump screens at 19 PWRs.[1] For particulate matter like paint chips, it's even worse: less than 10 percent of the particulate matter generated during a small-break LOCA will clog the containment sump screens at 31 PWRs.[2] For particulate matter generated by a large-break

[1] D. V. Rao, B. Letellier, C. Shaffer, S. Ashbaugh, and L. Bartlein, Los Alamos National Laboratory, "GSI-191: Parametric Evaluations for Pressurized Water Reactor Recirculation Sump Performance," Figure 5-10, August 2001.
[2] D. V. Rao, B. Letellier, C. Shaffer, S. Ashbaugh, and L. Bartlein, Los Alamos National Laboratory, "GSI-191: Parametric Evaluations for Pressurized Water Reactor Recirculation Sump Performance," Figure 5-11, August 2001.

LOCA, it's worst: less than 2 percent of the debris is needed to clog the containment sump screens at 41 PWRs.[3]

How likely is it that the debris generated during a LOCA will clog the containment sumps?
According to an NRC report:[4]

Containment Sump Failure Potential	Small-break LOCA	Medium-break LOCA	Large-break LOCA
Very Likely	36% of PWRs	45% of PWRs	77% of PWRs
Likely	10%	9%	10%
Possible	6%	9%	1%
Unlikely	48%	37%	12%

Thus, it is very likely that 77 percent of the PWRs experiencing a large-break loss of coolant accident will encounter containment sump failure due to clogging. Only 12 percent of the PWRs are unlikely to experience this problem.

What happens if the containment sump fails during an accident?
Containment sump failure during an accident either prevents or severely impairs the proper functioning of key safety systems needed to keep the reactor core and containment cool. When the reactor core is not adequately cooled, it can overheat and release its radioactive contents into containment. When the containment is not adequately cooled, it can overheat and discharge its radioactive contents to the atmosphere.

According to an NRC report, the potential for containment sump failure increases the probability of reactor core damage for the average PWR by nearly two orders of magnitude (i.e., a factor of 100) to 1.462×10^{-3} per reactor year.[5] Put another way, the probability of having a PWR experience core damage rises to 1 in 684 years. It is the NRC's current plan to have PWR owners fix the containment sump issue by March 2007.

Can the PWR containment sump problem be fixed in only one year?
Yes, it can and it has. The Davis-Besse nuclear plant is the only PWR is the United States to have addressed the containment sump problem and fixed it. The plant's owner determined Davis-Besse had a containment sump problem in September 2002.[6] Within a year, the plant's owner developed and installed an improved containment sump arrangement that features screens with 25 times the surface area. It takes much more debris to clog the larger sumps screens. In addition, the plant's owner removed lots of potential debris from containment and reinforced materials remaining inside containment to make it less likely that they will become debris in event of an accident.[7]

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[3] D. V. Rao, B. Letellier, C. Shaffer, S. Ashbaugh, and L. Bartlein, Los Alamos National Laboratory, "GSI-191: Parametric Evaluations for Pressurized Water Reactor Recirculation Sump Performance," Figure 5-12, August 2001.
[4] D. V. Rao, B. Letellier, C. Shaffer, S. Ashbaugh, and L. Bartlein, Los Alamos National Laboratory, "GSI-191: Parametric Evaluations for Pressurized Water Reactor Recirculation Sump Performance," Table ES-1, August 2001.
[5] J. L. Darby, W. Thomas, D. V. Rao, B. C. Letellier, S. G. Ashbaugh, and M. T. Leonard, Los Alamos National Laboratory, NUREG/CR-6771, "GSI-191: The Impact of Debris Induced Loss of ECCS Recirculation on PWR Core Damage Frequency," page D-6, August 2002.
[6] Letter dated November 4, 2002, from FirstEnergy Nuclear Operating Company to the Nuclear Regulatory Commission, "LER 2002-05 / Davis-Besse Nuclear Power Station, Unit No. 1 / Date of Occurrence – September 4, 2002."
[7] Letter dated May 21, 2003, from FirstEnergy Nuclear Operating Company to the Nuclear Regulatory Commission, "LER 2002-05-2 / Davis-Besse Nuclear Power Station, Unit No. 1 / Date of Occurrence – September 4, 2002."

So, the PWR containment sump problem can be fixed within a year. Davis-Besse proved it beyond a shadow of any doubt.

Why will the NRC take many years to fix a serious safety problem that can be fixed in less than a year?

The NRC's priority is on the financial health of the nuclear industry, not on public heath. The NRC began "solving" the PWR containment sump problem in September 1996 and currently plans on finally solving the problem in March 2007. That's 10.3 years – IF the NRC delivers as promised. A decade to solve a single safety problem affecting 68 pressurized water reactors and a problem the NRC ironically classifies as a HIGH priority. The absurdity of this pace is evident many ways, including the following ones:

- It took less than 10.3 years from the day that the NRC received the application to build the reactor for exactly half of the 68 PWRs afflicted with the PWR containment sump problem to split atoms for the first time. In other words, the NRC was able to issue the construction permits and then the operating licenses for these PWRs faster than they can resolve just one safety issue.
- The NRC has a goal of approving all requests by plant owners to amend their operating licenses (e.g. to reduce the frequency of safety tests and inspections and to increase the maximum output of the reactors) within 2 years. The NRC expects to get about 1,500 such business requests each year and to dutifully approve them ASAP.[8] The NRC meets this goal.
- The NRC has approved 20-year extensions to the original 40-year operating licenses for 12 of the 68 PWRs afflicted with the containment sump problem.[9] It took the NRC less than 3 years to review and approve these license renewal applications.
- It took less than 1 year for the PWR containment sump problem to be fixed at Davis-Besse.

Who is exposed to undue risk?

Anyone living near any one of the following PWRs is at unnecessarily high risk as long as NRC allows the reactors to operate seriously impaired by the containment sump problem:

PWR Name	Location
Farley 1	Dothan, AL
Farley 2	Dothan, AL
Arkansas Nuclear One 1	Russellville, AR
Arkansas Nuclear One 2	Russellville, AR
Palo Verde 1	Wintersburg, AZ
Palo Verde 2	Wintersburg, AZ
Palo Verde 3	Wintersburg, AZ
Diablo Canyon 1	Avila Beach, CA
Diablo Canyon 2	Avila Beach, CA
San Onofre 2	San Clemente, CA
San Onofre 3	San Clemente, CA
Millstone 2	Waterford, CT
Millstone 3	Waterford, CT
Crystal River 3	Red Level, FL
St. Lucie 1	Hutchinson Island, FL
St. Lucie 2	Hutchinson Island, FL
Turkey Point 3	Florida City, FL
Turkey Point 4	Florida City, FL
Vogtle 1	Waynesboro, GA
Vogtle 2	Waynesboro, GA

[8] Letter dated July 3, 2002, from NRC Chairman Meserve to the US Congress.
[9] See http://www.nrc.gov/reactors/operating/licensing/renewal/applications.html

PWR Name	Location
Braidwood 1	Braidwood, IL
Braidwood 2	Braidwood, IL
Byron 1	Rockford, IL
Byron 2	Rockford, IL
Wolf Creek	Burlington, KS
Waterford 3	Taft, LA
Calvert Cliffs 1	Lusby, MD
Calvert Cliffs 2	Lusby, MD
DC Cook 1	Bridgman, MI
DC Cook 2	Bridgman, MI
Palisades	South Haven, MI
Prairie Island 1	Red Wing, MN
Prairie Island 2	Red Wing, MN
Callaway	Fulton, MO
McGuire 1	Cornelius, NC
McGuire 2	Cornelius, NC
Shearon Harris	New Hill, NC
Fort Calhoun	Fort Calhoun, NE
Seabrook	Seabrook, NH
Salem 1	Salem, NJ
Salem 2	Salem, NJ
Indian Point 2	Buchanan, NY
Indian Point 3	Buchanan, NY
R. E. Ginna	Ontario, NY
Beaver Valley 1	Shippingport, PA
Beaver Valley 2	Shippingport, PA
Three Mile Island 1	Londonderry Township, PA
Catawba 1	Clover, SC
Catawba 2	Clover, SC
H. B. Robinson 2	Hartsville, SC
Oconee 1	Seneca, SC
Oconee 2	Seneca, SC
Oconee 3	Seneca, SC
Virgil C. Summer	Parr, SC
Sequoyah 1	Soddy-Daisy, TN
Sequoyah 2	Soddy-Daisy, TN
Comanche Peak 1	Glen Rose, TX
Comanche Peak 2	Glen Rose, TX
South Texas Project 1	Palacios, TX
South Texas Project 2	Palacios, TX
North Anna 1	Mineral, VA
North Anna 2	Mineral, VA
Surry 1	Gravel Neck, VA
Surry 2	Gravel Neck, VA
Kewaunee	Carlton, WI
Point Beach 1	Two Rivers, WI
Point Beach 2	Two Rivers, WI

What can you do?

If you work at the Davis-Besse nuclear plant, pat yourself on the back for voluntarily fixing a serious safety problem and being the first PWR in the United States to have done so.

If you work for the NRC, put aside the license renewal applications and power uprate amendment requests until this PWR containment sump problem is fixed.

If you are a member of the US Congress, ask the NRC why it is putting the financial safety of the nuclear industry ahead of the safety of millions of Americans.

If you live near one of the 68 PWRs, tell the NRC (opa@nrc.gov) or your US Senators and/or Representative that you want the NRC to fix the PWR containment sump problem THIS year.

What will UCS do?

UCS will try to get the NRC to fix the PWR containment sump problem sooner rather than later. And we will interface with the US Congress, the media, and people living around the unnecessarily dangerous reactors to try to pressure the NRC to fix this problem NOW.

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