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Oral presentation

Written submission Dr. Sunil Nijhawan

In the Matter of the

Ontario Power Generation Inc.

Application for a licence to construct one BWRX-300 reactor at the Darlington New Nuclear Project Site (DNNP)

Commission Public Hearing
Part-2

January 2025

Exposé oral

Mémoire de Dr. Sunil Nijhawan

À l'égard d'

Ontario Power Generation Inc.

Demande visant à construire 1 réacteur BWRX-300 sur le site du projet de nouvelle centrale nucléaire de Darlington (PNCND)

Audience publique de la Commission
Partie-2

Janvier 2025

Canada

Revised Intervenor Submission

on

OPG application for a license for Construction of a BWRX300 within the exclusion zone of the operating Darlington NGS.

Sunil Nijhawan, Ph.D. P.Eng.

to

Canadian Nuclear and Safety Commission

12 December 2024

A Canadian Nuclear Reactor Safety Engineer's Independent and Objective Review of the OPG Application to Construct BWRX-300 Reactors within Darlington Site

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Revised 12 December 2024

As a Canadian nuclear industry veteran, I am very alarmed that an OPG application to begin construction of a new nuclear power reactor, the BWRX-300 by GE-Hitachi has been submitted so prematurely, while the design is still incomplete.

The BWRX sports an incomplete and a highly vulnerable design unable to meet many important reactor safety norms and traditional public expectations of low risk. I would expect that the inadequacies of this design should be obvious to any impartial reactor safety analyst, despite the slick marketing behind it.

Since safeguarding public interest is fundamental to its mandate, CNSC must not permit start of construction until there is a completed and certified design, with thorough and independent scrutiny of the safety case, accident mitigation and performance claims. Such scrutiny should concentrate on vulnerabilities of the design, incorporating lessons learnt from previous BWR reactor accidents and premature BWR reactor closures for lack-of-safety reasons. US NRC staff has also cited a need to wait for a complete design, documenting its inability at this stage to license BWRX in its jurisdiction. Hopefully CNSC can also show the same common-sense restraint.

The choice of a Boiling Water design is problematic to begin with. The historic score card for BWRs is not stellar - 20 were cancelled, 5 suspended construction, 49 were shutdown and only 42 are still producing power with another 18 in 'suspended operation' pending safety upgrades. Let us not forget that 4 were lost at Fukushima Daiichi. BWRX is supposedly the tenth upgraded edition of a Boiling Water Reactor. Not all previous 9 versions remain on-line, and some – notably the ESBWR – were never built.

I have genuine reactor safety concerns about the BWRX-300. These concerns are borne out of almost a half century of experience in learning, participating in reactor designs, accident analysis, accident simulation code development and related professional work. So, as a professional engineer, and very pro safe-nuclear, I consider it is my moral duty to intervene to oppose this rush to build the first BWRX without (in my opinion) proper due diligence.

I have spent a year looking at the BWRX-300 design and the public pronunciations as well technical papers about its safety. At this juncture of my life, I consider it my duty to one more time offer to assist you the CNSC Commissioners, to avoid an ill-considered decision. Under the worst

conditions, it is a decision that could lead to a (not too unlikely) future disaster that could cripple Canada's industrial and financial heartland.

Most of the operating power reactors in the world today were designed over 40 years ago, when our understanding of so many of what we now consider scientific facts was limited or incomplete. Yet, almost all operating power reactor designs incorporated some fundamental safety features that are suddenly absent in the 'new' design of a BWRX. Those absent features include the Canadian requirement of two fully independent and equally effective reactor fast shutdown systems, an effective and broad-based emergency core cooling system, backup electrical power from diesel driven generators, reactor vessel over pressure protection systems and a robust containment, to name a few obvious ones. The fact that these are all absent from the BWRX design, or severely compromised, is very alarming indeed.

For example, a 'robust' containment must be of sufficient volume and structural strength to cope with severe accidents. It must have active and effective energy removal systems, controlled and efficient ignition-based hydrogen mitigation measures, aircraft and missile protection, significant pressure retention, leak tightness and much more.

Let us not forget that the Japanese parliamentary investigation termed the Fukushima Daiichi disaster 'man-made', caused by "collusion" between government, industry and regulator. Since then, Japanese regulatory authorities, responsible and caring of their people, required the addition of many new barriers to prevent a disastrous ending from a simple Station Blackout Scenario in their BWRs. These included hydrogen removal by passive autocatalytic recombiners (PARS) as well as filtered containment venting and a demonstrable ability to contain any credible accident from within, as well an ability to cope with an 'impact' from outside. Such considerations have no mention in the current BWRX design.

This BWRX design – a medium sized ~900 MWTh reactor with enriched fuel – has almost NONE of these customary safety features or equivalent proxies, yet retains vulnerabilities of many other older designs that have since been abandoned.

In addition, the BWRX 'dry' containment has a free volume that is about 10% of the size that it should be, according to credible estimates of scaled BWR accident progression and consequence assessments. Additional systems for immediate removal of accidental injection of energy into containment, or the sudden imbalance between energy input and removal from the reactor vessel, need to be incorporated. Without that level of basic protection, the design has inadequate standing. That lone Isolation Condenser system, even though triplicated, just cannot have the sharp, timely and adequate energy removal response one needs in a nuclear reactor.

The current incomplete BWRX design is a four-steps-backwards design. It eliminates four basic safety features that were present in earlier BWR designs, with nothing new added to the old BWR6 and ESBWR concept to justify the elimination of these safety features.

In the proposed BWRX design, a huge mass of water in 4 tank sets, including a set for spent fuel pool with about 3 years' worth of enriched spent fuel assemblies that will sit vulnerably on top of the containment building. (*Did we learn nothing from Fukushima? There, where the famed*

helicopter addition of water to the spent fuel bays of unit 4 reminded us of earlier BWR design follies. According to many, the claims of that BWR6 reactor piping survival after the 2011 earthquake and before the ensuing tsunami are now in question, as is the reliability of the fabled 'Isolation Condenser' system in Unit 1).

We must realize that the reactor vendor will not be held responsible for a devastating reactor accident in the heartland of Ontario, in case the claims made in the GE Hitachi sales brochures are not true. (*It is assumed that no sudden pipe or valve failures will take place in the so called "Break Exclusion Zones'. That arbitrarily shifts the most elementary reactor accident analysed – a LOCA – to beyond design basis considerations, with no prior assessments of accident progression and consequences; etc. I will speak more on this in my oral presentation in the meeting in January 2025*).

One needs to clarify if the top of the BWRX reactor vessel is outside the containment envelope and is separated from external forces by nothing more than a standard industrial building walls and roof not designed to withstand impact from an airplane or a small missile. For security reasons I cannot speak publicly in this presentation about the security and safety implications that I see in the reactor building structure, having spent the last decade looking at spent fuel pool accidents (*where the fuel is thankfully below ground in CANDUs*) and spent fuel storage issues but will be happy to discuss privately.

The bizarre vendor claims of eternal safety and piping/valve integrity in the so-called Break Exclusion Zones where failure of any pipe or valve is claimed to be incredible / inconsequential, is certainly not conservative or logical and its acceptance on face value is contrary to our country's interests. GE Hitachi claims that even fundamental hydro-dynamic reactions like a pipe whip cannot damage the appended isolation valves in a manner that creates a very undesirable system response. The reactor vendor decided to invoke perfection and eternal safety by referring to **a non-existent for <u>ANY</u> BWR, incredible large steam/feedwater pipe "leak before break" (LBB) crutch**, effectively eliminating consideration of a sudden large pipe break scenario. Is this sound engineering or just engineering euphoria? Or a total misrepresentation?

Remember - the application of LBB is limited to piping that is not likely to be susceptible to failure from various degradation mechanisms in service. That is not true for feedwater or steam pipes of the BWR. These pipes degrade by an unavoidable flow accelerated corrosion. *From the NRC experience, a significant portion of any LBB review involves the evaluation of the susceptibility of the candidate piping to various degradation mechanisms. The LBB approach cannot be applied to piping that can fail in service from such effects as water hammer, creep, erosion or corrosion excessive fatigue…**Currently, approximately two-thirds of the PWRs in the U.S. have approval for the application of the LBB concept in the primary coolant loop…. The application of the LBB concept has not been approved yet for any boiling water reactor (BWR)*** (*verbatim taken from reference* 1 – a good summary; many more references available on LBB]. As a nation we must develop our own understanding, but the data on flow accelerated corrosion and failures speak for themselves.

Easily available online are a dozen pictures of no leak before sudden power reactor pipe rupture and multiple descriptions of sudden pipe failures that not only devastated several power plants but also

killed, without warning 4 workers and injured 7 at Mihama nuclear plant in Japan in 2004. See Figure 2).

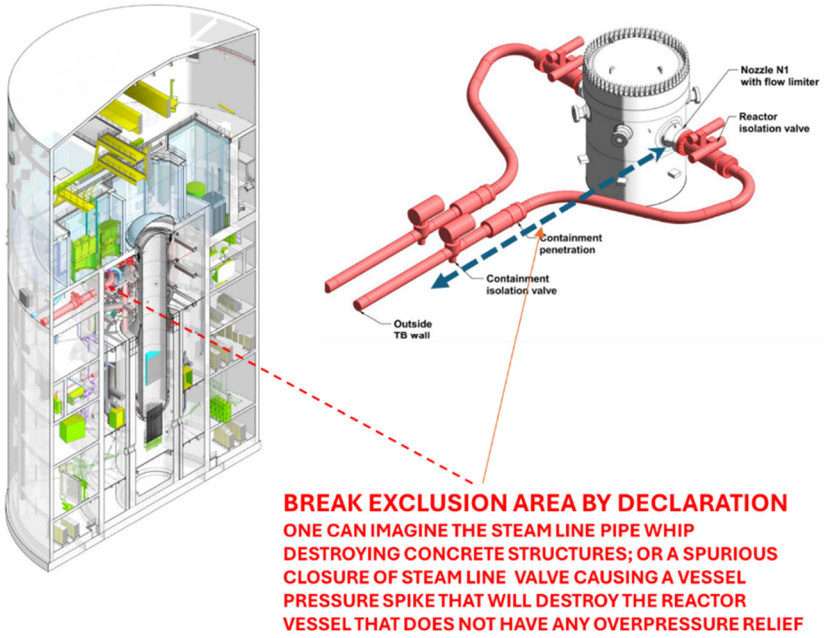


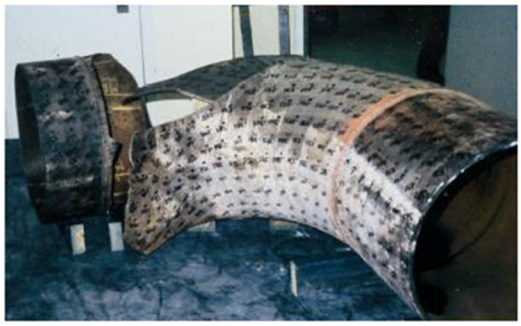
Figure 1 : Example of one of the 'Break Exclusion zones claimed by GE Hitachi.

As a veteran of Canadian nuclear industry, I can be all for a safe BWRX. But I am compelled to share my warnings about the consequences of not acting intelligently and in national / public interest. I concede that it is too late for a reactor siting discussion but I am hopeful that it is not too late to bring up what is never explicitly justified – of putting any reactor 100 feet below the water line of Lake Ontario, about 100 yards from the lake itself. Do we know how many times relatively shallow basements at Pickering reactors have been flooded? And how will the reactor structures of BWRX fare potentially submerged in water? And how we can ever decontaminate that site after an accident?

Safety systems have been inexplicably removed from BWRX that were intrinsic in its claimed predecessor, the 2011 US NRC approved ESBWR whose license was withdrawn in 2014 by NRC/GE Hitachi agreement after Fukushima. The deletion of most fundamental nuclear power reactor safety features allows GE Hitachi to achieve its celebrated 90% 'reduction' in volume in going from ESBWR to BWRX, making any claim of the BWRX being a derivative or offshoot of the ESBWR baseless. In my opinion, however, such safety system deletions cause at least a 1000 fold increase in risk to all stake-holders, including the innocent Canadian public, which has no option but to put its trust in the industry friendly regulator CNSC. Looks like the proponents have spent more energy on marketing than on engineering a safe reactor that we all in the reactor safety community can celebrate.

It must also be borne in mind that the Japanese Parliamentary Committee looking into the Fukushima disaster had sufficient information to conclude that there was structural damage, including burst pipes at Fukushima prior to the tsunami. The point is that a given reactor design is

not always as robust as advertised even for its design basis and the sales pitch of an ultra safe small modular BWRX-300 reactor proposal is a dangerous exaggeration. There need to be sufficient, properly demonstrated margins to ensure safety, without sacrificing level of redundancy that is mandated by design codes and regulations, not just glossy marketing claims. We in Canada are well versed in reactor safety issues and cognizant of our national interests and this design does not meet the most basic requirements.



18" elbow wall thickness decreased from 12.7 to 1.5 mm on feed-water pump inlet at Surry, 1986

Wall Thickness reduced from 10 to 1.5 mm on Feed-water piping at Mihama unit 3, 2004

Failure in a high pressure extraction line at Fort Calhoun in 1997

Failure downstream of the LCV in the reheater drain line at Millstone unit 2, 1991.

Failure of 14" heater drain extraction line to high pressure heater at Arkansas unit 2, 1986

Failure of the Feed-water Heater Point Beach Unit 1, 1999

Figure 2 : Examples of pipe ruptures at power plants without warning.

Even with gross simplifications and removal of critical safety systems, misrepresentations about the BWRX abound. More once more design information is made available. But for example, even the pressure boundary and the extent of the containment structure is likely misrepresented in the above figure. That is the least of the misrepresentations I have encountered. A common claim of the BWRX-300 reactor being a 'natural circulation reactor' is also misleading as the old BWR core recirculating pumps are out but recirculating flow around the core is powered by huge feedwater pumps and similarly pushed in a PWR boiler without they being 'in natural circulation'.

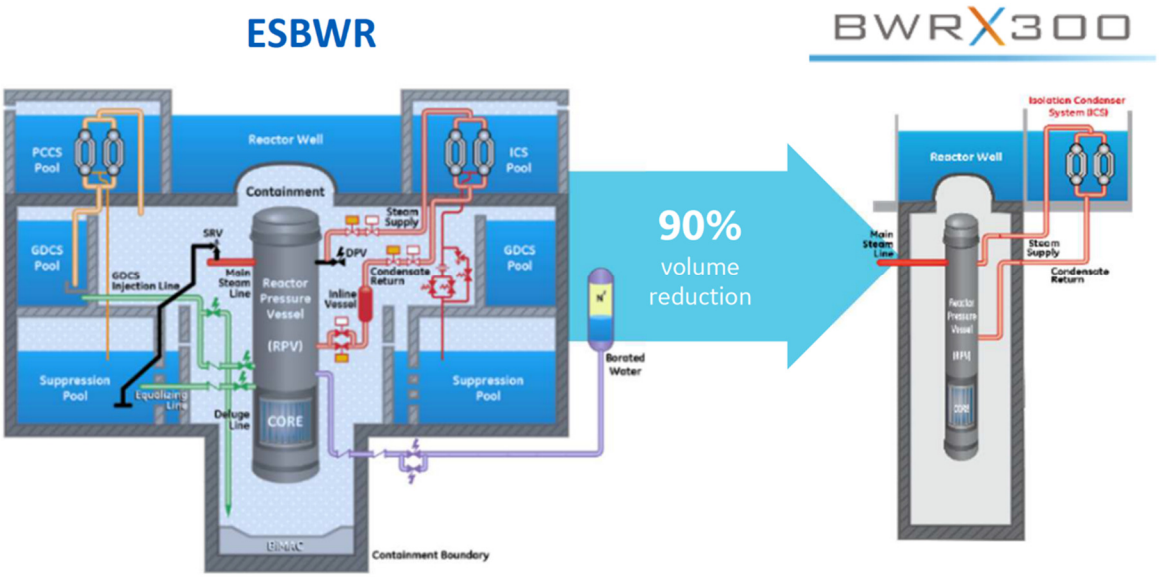


Figure 3 : In a rush to be small, some very sound safety elements from ESBWR were dropped. No real connection remains between the two.

Having followed with great interest, the progress that GE Hitachi has made in convincing Ontario government to promise to invest a billion in this design, I have previously commented to CNSC on the fallacy of the so-called Plant Parameter Envelope - PPE - approach in establishing certain design adequacies for the location. Please have the staff make that document available to you.

From the scant numerical data made available and miles of redacted safety assessment information under the guise of 'proprietary' information, the final design may be unduly constrained by what will be prematurely constructed (e.g. the bore hole size). If common engineering sense and CNSC legislated mandate prevails and a much larger and different containment volume along with a safer placement of spent fuel is deemed necessary, there may be inadequate functional space to allow for such a change.

A simple feedwater or steam pipe failure in that (unreasonably small) 5,600 m^3 free volume dry containment will likely cause enough structural damage and radiological contamination, from energy release and an overheating core, that will force a sudden abandonment of the site. That happened at Fukushima Daiichi in 2011 and in 1970 in a sister General Electric BWR design at Humboldt Bay in California. The Humboldt Bay reactor cleanup costs to the owner utility PG&E are at $1.6 billion already, ~30 times more than the original cost of that BWR. Like the planned

BWRX at Darlington, the Humboldt Bay reactor was similarly constructed next to operating conventional power plants. Those two plants are all gone now but with stacks of spent nuclear fuel is in storage next to the beach with nowhere to go and no designer taking any responsibility for that fiasco.

Without seeing the unredacted original, I see in the documentation made available, a design and an assessment process with no consideration of the lessons learnt from the many reactors that we have either shut down prematurely or closed contaminated due to poor design and 'avoidable' accidents with already prohibitive consequences. Even the process of rushing to begin the process of CNSC granting a license to begin construction of a very questionable design is in line with a failure to incorporate in our regulatory processes what Fukushima disaster taught us.

I went through scores of US NRC meeting transcripts, documents related to the 'joint' CNSC – NRC project to examine the BWRX proposal . I see here in Canada a need demonstrate compliance with safety norms including that of responsible regulatory bodies like the US NRC who have dutifully listened to GE Hitachi with a couple CNSC staff merely sitting in without ever seemingly adding any analyses to show compliance of the design to Canadian regulations) telling the proponent that the interactions do not mean an approval but a warning that actual, detailed assessment for compliance will await an application under 10CFR 50 or 52 that never came because I imagine any private funding would do due diligence and walk away from it.

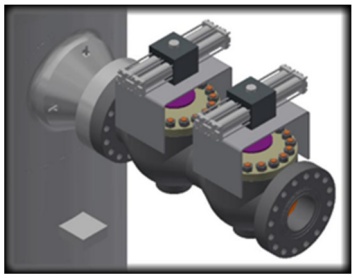


Figure 4 : Isolation valve attached to the pressure vessel.

Here is a GE Hitachi artist's rendition of a BWRX pipe isolation valve that is, according to GE Hitachi considered 'integral' to the BWRX pressure vessel and hence 'fail proof'. That begs the question - how can a bolted-on valve be considered integral to the body of the huge pressure vessel it is attached to? Besides, failure mechanisms for such a valve work independently, consistently and with likely immediate, fast acting and disastrous consequences that cannot await any slow acting 'passive' mitigation system like the only available defence in this reactor, their fabled isolation condenser.

The argument about the Containment isolation valves being 'integral to the reactor pressure vessel' and hence infallible, ignores so many modes of valve failure. The risk of failure is especially acute, but not limited to a valve that is constantly in the path of hot, high velocity fluids – while subjected to structural stresses, corrosive environments, undergoing erosion and yet never capable of being subjected to any interior inspections. Valve failure data are abundant. It is not commonly known, perhaps not even to the Commissioners, that reactor pressure boundary isolation valves (LRVs) in CANDU reactors have caused at least 4 LOCAs due to inadvertent actuation. The Commissioners can ask the staff if they know about that fact.

It is worrisome enough to have a grossly faulted siting. *The proposed BWRX switchyard will be a stone's throw from a CN/CP railway line and the reactor building will be within shouting distance of an aging 4-unit nuclear power plant with its own vulnerabilities.* We will all be concerned for many years about the safety of thousands of construction workers next to an operating reactor with a containment 500 times leakier by design than any other modern reactor containment. Of course, the owner utility owners bear the risk of the possible loss forever or limited access/use also of one reactor after an accident in another. Emergency management agencies that must take over responsibility to protect the public in case of an accident will wonder about the common-sense of separating treasures / hazards. And then there is the matter of US 10 CFR part 100 'Reactor Site Criteria' requirements, including those to keep reactors far from each other's exclusion area boundaries. As a nuclear safety engineer, I cannot fathom how this reactor claims a tiny 300m exclusion zone overlapping Darlington's, without even having a certified design. For sure, the multiple nuclear reactor core damage accidents in our lifetime have taught us a thing or two about paucity of existing 1000 yard exclusion zones, redrawn shrunk conveniently at Darlington and relics of a similar past indifference.

My concerns are consistent with clearly stated the US NRC staff position in that it is too early to conclude that there is compliance with regulatory requirements in the absence of a complete design followed by a thorough independent evaluation. NRC staff have made it clear that the US regulator would not yet issue a license to allow construction without a completed design.

We must honestly ask if the following design features at BWRX are acceptable:

- No overpressure protection by pressure relief valves on the primary coolant circuit or on the reactor pressure vessel
- No overpressure protection pressure relief valves on the containment.
- No Emergency Core Cooling System.
- No emergency AC power by diesel generators or otherwise.
- Tiny containment justified by 'BEZ' and zero large-break LOCA considerations and of course no lessons from Fukushima explicitly drawn
- Dependence on the triple loops of an Isolation condenser system that may not function with the desired speed or necessary effectiveness – or at all.
- Reactor located next to a lake in a water-filled pit over 35 meters deep about 30 m below the water line.
- A thousand spent fuel assemblies in a pool above ground level where a single missile/aircraft impact can create a radiation disaster affecting lake Ontario and about 5 million residences and businesses of Southern Ontario.

The OPG application is largely based on information provided by the vendor – GE Hitachi –who has made some outlandish claims about the reactor design. I respectfully submit that the design is not only incomplete but also wanting of critical safety systems necessary to operate this reactor with a sufficient degree of confidence that no undue risk is posed.

Another issue of course is the paucity of available BWRX design documentation – severely redacted as it is, as if any giving out numerical information would be equivalent to divulging hydrogen bomb secrets. In 4 decades of reactor design and safety assessments, I have never seen such secrecy over mundane reactor parameters and safety assessments. I understand that there just may not much there to divulge. I have more information available in public literature about new reactors in Asian

countries than I have for one that is being proposed for mine. This serves no purpose in this time and age when technical information about almost all other reactors is so abundantly available. In this specific case I was not able to tell you in how many seconds would the isolation condenser be overwhelmed by an inadvertent closure of isolation valve in the steam line and how long would that take to rupture the reactor pressure boundary in absence of an engineered overpressure protection by a set of pressure relief valves so fundamental to a process system. I could not tell you how the low partial pressure of steam in the non-condensable filled isolation condenser filled would cause minimal condensation in the critical initial period.

The US NRC staff who did more comprehensive evaluations than the CNSC staff, seem to be largely in agreement with me. The emerging consensus we have (consistent with clearly stated NRC staff position) is that it is too early to permit construction. This application for a licence to construct must be rejected to safeguard our national interests.

The vendor needs to demonstrate an enhanced understanding of modern reactor safety requirements and risk assessment issues including lessons from their own BWRs at Fukushima and other locations. GE Hitachi must upgrade the design and the CNSC staff must up their game.

Having worked at the OPG predecessor Ontario Hydro for about 10 years and worked on safety issues for almost all Canadian reactors, I know OPG will need help in making the right decision. I hope this submission helps them rethink this project in their own corporate interests and that of people of Ontario who will benefit or suffer from the decision the present management will make or have their friends at CNSC make for them.

We have mind boggling claims for a "Small Modular Reactor" that is really not SMALL yet marketed as such, with almost all reactor safety systems removed; and the design is certainly not MODULAR because nothing in a reactor of this size can be or produced in large quantities. In my professional opinion, this is a reactor designed and marketed with GE Hitachi interests for a quick launch of their design as the primary consideration, at the exclusive expense of Canadian public financial and safety interests with all risks borne by Canada.

To me, my country comes first and therefore I demur for all the public safety reasons I summarized above.

I will make an oral presentation related to this submission at the public hearings in January 2025 and submit supplementary submissions beforehand if necessary or requested by the Commissioners.

Sincerely,

Sunil Nijhawan, Ph.D., P.Eng.
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REFERENCES

1 An Historical Survey of Leak-Before-Break in Nuclear Plant Piping ; https://www.power-eng.com/news/an-historical-survey-of-leak-before-break-in-nuclear-plant-piping/