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50-267

March 14, 1984
Fort St. Vrain
Unit #1
P-84084

RECEIVED
MAR 19 1984

Mr. John T. Collins
Regional Administrator
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Dr., Suite 1000
Arlington, Texas 76011

SUBJECT: Fort St. Vrain Unit No. 1
NRC Source Term Studies

REFERENCE: P-84036

Dear Mr. Collins:

As a result of the above referenced letter we received inquiries from your staff that indicated they could not determine who in the NRC was working on the source term studies. The attached articles from Inside NRC are enclosed for your information.

Very truly yours,

Don W. Warembourg

Don W. Warembourg
Manager, Nuclear Production
Fort St. Vrain Nuclear
Generating Station

DWW/djc

Attachments

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INSIDE N.R.C.

R.C.

elusive report on the U.S. Nuclear Regulatory Commission

Vol. 6, No. 2 – January 23, 1984

~~Lee~~ Belleview

Warembourg FSV

~~Brey~~ Diamond Hill

~~Holmes~~ Diamond Hill

From Public Affairs 620

Call Changes to X 7389

IVERSION TO FOSSIL FUEL SEEN IMMINENT

in Ohio will decide its future by the end of the month. William Dick- nati Gas & Electric, has told the Cincinnati City Council. Other sources plans to complete it as a nuclear unit and are working out the economics abandoning it altogether.

lled over rising cost estimates for finishing the plant. CG&E and its part- umbus & Southern Ohio Electric, have already invested nearly $1.7-billion lete. But Bechtel, brought in to complete construction after an NRC- mated $1.2-billion to $1.8-billion more will be needed (Nucleonics Week, ing that estimate is too low and the Cincinnati City Council is consider- ndon the plant as "clearly unaffordable" for ratepayers. The Ohio Con- nsultant Charles Komanoff and MHB Associates to analyze the Bechtel ffice representing utility customers before the Ohio Public Utilities Com- opposing charging ratepayers any costs attributable to mismanagement. nmer costs. In addition, DP&L and C&SOE have forced CG&E into pri- osts and possible damages for alleged CG&E mismanagement.

&L and C&SOE met for seven hours Jan. 18 and all refused to speak to the meeting room. A CG&E spokesman said no decision had been made planned. Any decisions will have to be approved by all three utilities' boards her sources said the decision not to continue with Zimmer as a nuclear te now is centered on whether to convert the plant or abandon it. DP&L verting the plant to gas for peak demand now and converting it to coal later. The conversion idea is made more attractive, sources said, by an Ohio law that forbids utilities from recouping costs of a canceled plant from ratepayers.

Rumors of Zimmer's imminent demise were spurred by Public Service Indiana's decision last week to cancel the half-completed Marble Hill plant after PSI and a group of municipal cooperatives had spent nearly $2.9-billion (Nucleonics Week, 19 Jan., 1). PSI decided it could not afford to continue building. Safety-related work at Zimmer has been stopped since November 1982, when the NRC commissioners ordered a halt until Zimmer management could be audited and revamped, and until an outside company could assess the quality of construction at the 810-Mw Mark II BWR. A management reorganization was approved by NRC last month, with NRC officials saying CG&E and Bechtel had brought in experienced personnel who could get Zimmer built correctly (Nucleonics Week, 22 Dec. '83, 4). – *Margaret Ryan*

STAFF PROPOSES SOURCE-TERM RULE THAT WOULD COVER OPERATING PLANTS

A source-term rule, specifying the fission product emission expected for severe accidents at all reactors now operating or under construction, will be proposed by NRC staff. The rule would state the maximum risk expected from any plant, using data derived from six "reference plants," and the need for any backfit proposed to reduce severe accident risks would be judged against the risks in the source-term rule.

That strategy is part of the latest draft of NRC's proposed severe accident policy, which would postpone consideration of measures to mitigate, manage or prevent severe accidents until the source term rule is enacted. The draft sets out a decision-making process by which the staff would weigh relative costs and benefits of possible backfits, using mostly traditional engineering analysis but also probabilistic risk assessment (PRA). It specifies that decisions would be made using reference plants rather than requiring plant-specific analyses

INSIDE THIS ISSUE . . .

at all operating reactors. It also proposes a "safety assurance program" for new standard design plants that could be extended to plants already in operation. Any backfits the staff thinks are worthwhile would be enacted through a rule, and, until severe accident decisions are made, the draft would ban Atomic Safety & Licensing Boards from litigating contentions about a plant's response to severe accidents.

Robert Bernero, head of the source-term revision effort, told an Advisory Committee on Reactor Safeguards (ACRS) subcommittee at a Jan. 11 briefing that his staff was considering a methodology, a set of tables, or both for the source-term rule. The tables could specify "acceptable results for fission product transport for use in plant-specific calculations." The table idea is complicated, he said, by the fact that different tables are needed for each reactor and containment combination, and that fission-product transport calculations vary with time and accident sequence. As a result, his staff is considering some combination of tables and methodologies which could be used for any plant-specific analysis. In its final form, however, the rule "will represent the source term for existing plants, derived from the careful evaluation of severe accident risk characteristics for a representative set of those plants," the latest severe accident draft says.

The staff would withdraw the severe accident rulemaking proposed in 1980, because "it has become increasingly clear that the regulatory concepts in (the 1980 proposal) were undesirably amorphous and unfocused," and modifications made since the Three Mile Island-2 accident have already reduced the risk of severe accidents. Utilities put together the Industry Degraded Core Rulemaking (Idcor) program in response to that 1980 proposal, and industry officials have been pressing NRC officials to return to the single rule concept (INRC, 26 Dec. '83, 6). However, the new proposal also rejects the other extreme – plant-specific analysis for all issues – though it leaves the option for further analysis open where even the staff finds it appropriate.

The draft proposal parallels earlier versions by stating that no "major redesign needs" for the current generation of plants are expected for ongoing severe accident research. 'It is possible – though not necessarily likely for any or all classes of nuclear power plants – that new information will demonstrate the desirability of certain lesser changes such as improved reliability of some engineered safety features and addition of filtered vents to some types of containment and design features that would reduce the risk from sabotage and earthquakes," the draft says, adding that research could pinpoint "worthwhile refinements" in current designs as well.

Earlier versions of the severe accident policy were criticized for not laying out the decision-making process for any backfits in sufficient detail (INRC, 18 April '83, 4), and the latest draft sets out three steps for deciding on the safety of existing plants: engineering analysis of performance of existing plants, analysis of existing PRAs for generic insights, and development of policy papers on important aspects of plant safety. After those steps, the staff will put together a policy paper stating NRC's expectations about the ability of current plants to cope with severe accidents. Then, according to the draft, the staff will analyze possible improvements, possibly using a "decision analysis method" yet to be developed, and will make recommendations to the commission. The proposals specifies that any backfits would be enacted through a public rulemaking, but there is no specific provision for outside review of measures the staff does not think are warranted, an omission Commissioner James Asselstine objected to in the previous draft.

Decisions to bring backfits to the commission will be made in part based on cost-benefit analyses, done in line with the analyses required by the Committee to Review Generic Requirements, the draft says. However, it says benefit estimates will not be pegged to any single formula, such as the one used in proposing $1,000 per man rem averted as a cost-benefit measure in the commission's proposed safety goals. It also says costs need not be known more precisely than within a factor of three. "Rather, the range and variety of such conversion factors will be treated on the same footing as other sources of uncertainty," the draft says.

Recognizing that both engineering analysis and PRA involve uncertainties, the draft sets out is philosophy. Its precepts are:

– The most cost-effective regulations are preferred.

– Realistic estimates of costs and benefits are preferred, to avoid either over- or underregulation.

– Uncertainty reduction has a value, whether it involves a backfit reducing the uncertainty in an engineering analysis or a change that will ensure regulations themselves are more stable and less uncertain. Measures that "strengthen defense-in-depth, or otherwise strengthen the diversity with which safety is assured, are to be preferred over those which concentrate protection in fewer safety functions," and features that handle broad classes of accidents are preferable to those that handle specific vulnerabilities.

– Early implementation is preferred, since the value of measures taken an operating plants is higher if they are done earlier in a plant's operating life.

– Measures that minimize rule changes are preferred, since new requirements that change the mix of personnel skills needed in both industry and NRC are difficult to accomplish.

– Measures that can be really verified are preferred, since ambiguities can lead to controversy, delays and costs.

– Regulations ought not to be unnecessarily prescriptive. When the NRC staff cannot make a clear-

cut decision among options based on the six principles above, this principle will be brought into play. The draft says, "It is a poor regulatory philosophy to narrow the options of the regulated industry unnecessarily. Doing so discourages innovation and diminishes the sense of responsibility in the regulated industry." As a result, NRC will lean toward asking applicants to come up with approaches for new plants and giving utilities with operating reactors alternatives among which to choose. "Where residual uncertainties leave the choice among alternatives ambiguous, performance objectives will be specified by the commission with the choice of implementation approaches to be left to the licensees," the draft says.

A major new proposal in the draft is a "safety assurance program," proposed by Roger Mattson, head of the severe accident effort, and Frank Rowsome. The draft, as did previous versions, proposes that new standardized designs be approved through rulemaking so they can be referred to in future construction permit applications. The proposal would use the techniques adapted from reliability engineering in the aerospace industry to make sure that the margins of safety calculated for standard plants when their designs were approved are not degraded by choices of components, construction, or operations. "Since it is contrary to the concept of a certified design to call for an extensive new licensing safety analysis of the design as it is readied for commercial service, it is necessary to require in the rule certifying the design those subsequent institutional checks and balances that assure the original safety analysis assumptions remain valid with the further (definition) of design detail," the draft says.

Those same techniques could be used to tailor severe accident decisions to individual reactors, the draft says. The techniques include plant-specific safety analysis and feedback of experience into plant operations to make sure safety analysis assumptions are valid, the draft says. Pilot programs are under way at Consumers Power's Big Rock Point, Consolidated Edison's Indian Point-2, and New York Power Authority's Indian Point-3, the draft says, and NRC is looking at the concept in the Integrated Safety Assessment Program now being explored (INRC, 25 July '83, 5). – *Margaret Ryan*

DENTON DELIVERS 'EARLY SECOND GUESS' TO PROMOTE BWR PIPE SWITCHES

The NRC commissioners have approved a staff plan aimed at allaying concern of BWR owners that "switching out" cracked primary system piping will subject them to hearings on license amendments (INRC, 14 Nov. '83, 5). Harold Denton, director of NRC's Office of Nuclear Reactor Regulation, said the "early second guess" of how the agency would treat pipe replacement under its regulations would provide "maximum flexibility" to encourage BWR owners to switch to nuclear-grade piping.

So, in a forthcoming letter, NRC staff will tell BWR owners: "We encourage programs to replace piping so as to minimize the potential for cracking and we will expeditiously review any submittals provided to us so as to not delay this important improvement program. . . . Prior NRC approval is not necessary unless the proposed change to the facility involves an unreviewed safety question or a change in technical specifications." Licensees, however, will be required to submit a radiation-protection plan to NRC before work is begun, and those who cannot keep estimated cumulative exposures to less than 2,000 man-rems will be required to meet with the staff to resolve the issue.

After discussing the proposed letter, the commissioners asked the staff to make it clear that the agency is issuing "selective and not complete guidance" on how utilities should treat a pipe switch under 10 CFR 50.59.

Inside N.R.C.

An exclusive report on the U.S. Nuclear Regulatory Commission

Vol. 5, No. 22 – October 31, 1983

TWO REPORTS FIND PROPOSED PRICE OF AVERTING DOSES TOO HIGH

Two draft research reports say that $1,000 per man-rem averted – NRC proposed standard for calculating benefits from backfits – is too high by at least a factor of 10. The reports will urge NRC commissioners to reduce the $1,000 to $100 or $50 per man-rem averted, about what industry has been urging.

The studies are being done by Science Applications Inc. and the Pacific Northwest Laboratory. The SAI study involves methods for factoring worker exposures into safety analyses, while the PNL study, draft Nureg-0933, covers methods for settling priorities for dealing with generic safety issues. In looking at the dollar value placed on human life in other federal standards, Jerry Cohen of SAI told NRC's safety research meeting last week, SAI researchers found figures as low as $300 used in highway cost-benefit formulas. In contrast, the NRC standard works out to $5-million per death averted. That figure would be reduced to $500,000 by the SAI proposal to put the value of a man-rem averted at $100, and to $250,000 by the PNL draft proposal to place it at $50, though the latter researchers say any figure between $10 and $125 would be reasonable.

NRC is using the $1,000 figure now in test cost-benefit – or "value-impact" – studies of proposed new regulations and backfits. The figure is used in the commission's proposed safety goals.– *Margaret Ryan*

THE JUSTICE DEPARTMENT HAS GONE TO COURT TO ENFORCE 26 SUBPOENAS by the NRC of present and former Three Mile Island-2 employees in its investigation into possible falsification of leak rate reports there before the 1979 accident.

The action follows a Sept. 21 refusal by the NRC commissioners (Commissioner Victor Gilinsky was not present) to quash 47 subpoenas NRC had issued after it decided earlier this year to reopen its investigation into the falsification allegations. In making that decision, the commissioners rejected arguments that reopening their civil investigation and requiring testimony would conflict with the two-year-old criminal investigation being pursued by a federal grand jury in Pennsylvania.

When NRC asked Justice two years ago to look into possible criminal wrongdoing at TMI, it was under the impression that Justice did not want the NRC civil investigation to continue, the commissioners said. NRC has since learned that Justice has no objections to continuing the civil investigation and NRC wants to investigate the charges before those involved forget what happened. The allegations relate to the ongoing enforcement proceeding involving Three Mile Island and must be resolved before a final decision on TMI-1 restart can be made, they added. The commissioners did agree to allow those no longer living in the TMI region to respond to their subpoenas in the court nearest them.

The court action by Justice is simply the next step in the progression of the investigation, NRC sources said. The U.S. District Court for the Middle District of Pennsylvania was asked to issue a show cause order to the 26 employees still living in the area, sources said, and NRC will probably wait to see how that action goes before it pursues the other individuals now scattered "throughout the United States." NRC has no enforcement authority of its own on the subpoenas but if the court issues a show-cause order and upholds the NRC's requests, they said, anyone failing to respond to the subpoenas can be charged with contempt of court.

– *Frances Seghers*

NRC'S SOURCE-TERM STUDIES RAISE HOST OF NEW QUESTIONS

NRC-sponsored source-term research is raising as many questions as it is answering, with researchers reporting new phenomena needing study before conclusions can be drawn. At NRC's safety research meeting

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in Gaithersburg, Md. last week, NRC researchers said they still expect to have recommendations on source-term changes to the NRC commissioners in the middle of next year, even though they have found new questions in the middle of the project. But no one was guessing how much of a change might be recommended, with new discoveries pushing estimated releases both higher and lower.

Researchers at the Battelle Columbus Laboratories are trying to integrate the mechanistic codes describing different aspects of reactor and fuel behavior in accidents. Battelle's James Gieseke said they are already recalculating their first set of results, of accident sequences at Surry-1, a PWR with a large, dry containment, because of code improvements involving better information on primary flow rates and temperatures. The changes produced some lowering of expected releases in some sequences, where releases already were below a thousandth of core inventory of the highest activity fission products. But Gieseke said BCL researchers had learned mostly that large uncertainties remain in the codes and decisions made by researchers along the way have big effects on results.

T.S. Kress of the Oak Ridge National Laboratory agreed with other speakers who said the basic thermal-hydraulic code that feeds into all other codes, NRC's March code, tops the uncertainty list. A major inadequacy is its failure to model changes in core geometry as a melt progresses, changes that could be a "strong driver" of source terms, he said. No code models strong recirculation flows that researchers expect inside a vessel, Kress said, and research data on core-concrete interactions and fission product chemical interactions is lacking.

Robert Wichner of Oak Ridge said the group studying fission-product transport had "belatedly" recognized that high-energy photons in a vessel would change fission product chemistry "dramatically," and that some experiments had to be redone. Wichner and R.J. Lipinski of Sandia National Laboratories said that a possibility just recognized is that aerosols containing fission products, which had settled out of the atmosphere, would be resuspended by the sudden pressure changes when a molten core melted through a reactor vessel. Until now, source terms for aerosols uniformly decreased with time, but Lipinski said researchers are looking at the possibility that up to 5,000 kilograms of aerosols could be resuspended late in an accident sequence.

Lipinski added that researchers also are looking at natural circulation from the core to the plenum, which could increase fission-product retention by a factor of 100 over earlier expectations. But they are also looking at whether decay heat might revaporize fission products that plate out on reactor internals.

S.J. Niemczyk of Oak Ridge said researchers had discovered that automatic fire-suppression sprinklers could come on during an accident and provide substantial scrubbing of fission products from the air, even though that is not what they were designed for. The problem is predicting what sprinklers will do, she said, since they are automatic and come on with heat buildup. In addition, they are only installed in some compartments of plants. Niemczyk said researchers, who are using Browns Ferry-1 for their study, are looking at possible "secondary" leakage pathways for fission products, such as escape through main steam line isolation valves to the turbine building.

Dana Powers of Sandia said attempts to pin down fission-product chemistry were complicated because researchers could not anticipate what impurities in coolant water would affect chemical reactions. While cesium hydroxide can react with stainless steel and boron carbide (in control rods) to form stable compounds, reducing the source term, cesium-iodine reactions with those surfaces appear to produce free iodine, he said. What happens to that iodine is not yet known. Another high-activity fission product, tellurium, is released late in a core melt but can bond either with stainless steel and Inconel, in which case it would plate out harmlessly, or with silver or tin from control rods, in which case it would become an aerosol and available for release.

P.C. Owczarski of Pacific Northwest Laboratory said his work on a code modeling supression-pool scrubbing had raised a key question: whether scrubbing continues throughout an accident. If accumulations of fission products in a pool act as surfactants, "stiffening" the surface, it could significantly reduce the pool's ability to scrub fission products as an accident progresses, he said. Lipinski, who is working on sensitivity studies of code uncertainties, said there is uncertainty in some instances whether, when water hits melt material, it produces scrubbing or a steam explosion.

Joseph Jung of Sandia reported hitting analytical limits in his attempts to determine containment pressure limits, a key component of source-term estimates. Jung calculated stresses on three different types of containments: a ring-stiffened steel containment at Watts Bar; a reinforced concrete structure at Maine Yankee; and a prestressed concrete containment at Bellefonte. While he was able to analyze the two Tennessee Valley Authority plants fairly well, estimating failure of Watts Bar between 120 and 140 psig and of Bellefonte at 130 to 139 psig, he found inadequacies in the state of the art of concrete analysis in examining Maine Yankee and had to stop the analysis "due to numerical instability."

NRC researchers have added a study of containment failure to their source-term work, with two working groups trying to estimate probability distributions for containment capacities and loading for different

types of containments. Gieseke reported that codes had to be modified when PNL researchers got to an ice-condenser containment because they found fission product plate-out on the ice bed. Some other results cited by Gieseke included:

– For a Mark I BWR, iodine and cesium compounds were scrubbed out by the suppression pool. However, tellurium, which is released later, was available when a release path through the drywell opened. However, 50% of the tellurium plated out in the drywell.

– For a BWR with a Mark III containment, no bypass paths around the suppression pool have been identified. As a result, fission products are expected to plate out in the reactor coolant system or to be scrubbed in the suppression pool, leading to releases below 1% of fission-product inventory of cesium iodide, cesium hydroxide and tellurium.

– Analysis of a sequence leading to basemat melt-through in a PWR with a large, dry containment showed substantial plate-out in the upper plenum and the primary system leading to very small releases if containment breach is delayed.

THE PROBABILITY IS 'PRETTY HIGH' THAT A TEMPORARY OPERATING LICENSE could be needed for the Catawba plant, Duke Power officials say, but spokesman at three other utilities listed as potential applicants for TOLs aren't so sure.

During recent congressional hearings on the NRC authorization bill for FY-84 and -85, when extension of the provision allowing the issuance of TOLs was discussed, Catawba-1, Shoreham, Limerick-1 and Comanche Peak-1 were cited as four plants nearing completion for which utilities could possibly need TOLs to load fuel and go to low-power testing. Catawba officials expect to be able to load fuel by next May but don't expect the licensing process for the plant to be complete by then. Hearings on most issues are already going on, but no hearing on emergency planning has ever been scheduled. The utility would like the emergency planning hearings set for early next year but intervenors are pushing for later in the year, a utility spokesman said, increasing the possibility that Duke Power will apply for a TOL to avoid a delay of as much as two months.

The Texas Utilities Generating Co., owner of the Comanche Peak station, hasn't yet made a decision on whether to apply for a TOL but hopes to see the provision for it extended in the authorization act. Esti-

SOURCE TERM STUDIES FIND VALIDITY TO SOME WASH-1400 'WORST' ACCIDENTS

NRC source term research, still in draft form, is showing that the worst case radiation releases predicted by the 1975 Reactor Safety Study will not materialize in most severe accidents at PWRs but could happen in some accidents at older BWRs. NRC contractors are still reviewing their methodology, however, particularly in light of a phenomenon discovered by the industry-sponsored Idcor effort that has led Idcor to tentatively predict higher releases in some categories than NRC.

The draft analyses, produced by Battelle Memorial Institute for NRC, use the results of experiments in fission products and transport in computer models more sophisticated than those available 10 years ago when the Reactor Safety Study, also known as Wash-1400, was being put together. Comparisons with the older study are rough, sources say, because the understanding of severe accidents has changed so much. However, the analyses of selected severe accident sequences at three PWRs show drops in expected releases of an order of magnitude or more in many cases. Researchers now expect fission products in a severe accident to remain in the reactor coolant system or the containment, settling on or chemically bonding with surfaces.

But there are glaring exceptions in accident sequences where the containment is bypassed in PWRs and the suppression pool bypassed in BWRs. Accident sequences called ABβ, in which a hot leg pipe breaks and all engineered safety features are lost at the same time containment isolation fails, and V, in which a check valve between the reactor coolant system and the emergency core cooling system fails and opens a path for fission products to the auxiliary building, produced the highest potential releases in an analysis using Virginia Electric Power's Surry plant as an example. In the higher V sequence, 52% of the iodine (as cesium iodide), 43% of the cesium (as cesium hydroxide) and 5.8% of the tellurium are estimated to reach the auxiliary building. In Wash-1400, those releases were put at 70%, 50% and 30% respectively. However, in the latest draft of the Battelle study, designated BMI-2104, researchers have attempted to estimate how much of those key fission products would be retained in the auxiliary building. They show only about 7% of the cesium and iodine compounds and 4.4% of the tellurium retained in the V sequence. Retention of up to 30% of the cesium and iodine and 12% of the tellurium are estimated for the ABβ sequence if the containment and auxiliary buildings are divided into two model areas, and about 4% more each if they are divided into four areas.

SUMMARY OF RELEASE FRACTIONS FOR A SURRY UNIT

Sequence	Species	Fraction of inventory released	Wash-1400 release fraction
ABε	I	4.8×10^{-5}	8×10^{-4}
	Cs	4.8×10^{-5}	8×10^{-4}
	Te	4.0×10^{-5}	1×10^{-3}
ABγ	I	8.7×10^{-2}	0.7
	Cs	8.5×10^{-2}	0.5
	Te	7.0×10^{-2}	0.3
ABβ	I	8.7×10^{-2}	0.7
	Cs	8.5×10^{-2}	0.5
	Te	7.0×10^{-2}	0.3
$AB\beta_\eta$ *	I	5×10^{-2}	0.7
	Cs	5×10^{-2}	0.5
	Te	4×10^{-2}	0.3
ABβ **	I	0.37	0.7
	Cs	0.37	0.5
	Te	0.19	0.3
TMLB 'δ	I	4.7×10^{-2}	0.7
	Cs	4.4×10^{-2}	0.5
	Te	0.11	0.3
TMLB 'ε	I	2.6×10^{-3}	8×10^{-4}
	Cs	5.3×10^{-4}	8×10^{-4}
	Te	7.9×10^{-2}	1×10^{-3}
$S_2D\gamma$ (Hot Leg)	I	4.2×10^{-5}	–
	Cs	6.4×10^{-5}	–
	Te	3.3×10^{-2}	–
$S_2D\epsilon$ (Cold Leg)	I	1.5×10^{-8}	2×10^{-5}
	Cs	1.4×10^{-8}	1×10^{-5}
	Te	7.7×10^{-8}	2×10^{-5}
V	I	0.52	0.7
	Cs	0.43	0.5
	Te	5.8×10^{-2}	0.3

* *Uses containment model with four control areas; ABβ uses two.*

** *With no credit taken for attenuation in auxiliary building.*

BWR sequences are being recalculated and NRC sources expect the numbers there to change, but they say the recalculations cannot avoid the suppression pool bypass problem. In Mark IIIs, that bypass is considered a very low probability, and the first draft of analyses using Mississippi Power & Light's Grand Gulf-1 as an example did not include any sequences in which the pool was bypassed. NRC researchers are now analyzing a sequence that includes a partial bypass. But analyses of a Mark I plant, using

Philadelphia Electric's Peach Bottom-2 as an example, find bypassing a potential problem in each of three sequences.

The drafts, and NRC and industry sources, all caution there are many modeling uncertainties for BWRs, including how to handle lower plenum and control rod drive structures, molten core behavior, and suppression pool scrubbing efficiency. But in the early Peach Bottom analyses in event TW-gamma prime, which involves failure of the residual heat removal system and a consequent pressure buildup that causes containment failure directly to the atmosphere, researchers estimated as much as 28% of the cesium and iodine compounds, and 18% of the tellurium, could escape. In sequence AE, involving a large loss-of-coolant accident (loca) combined with emergency core cooling injection failure and failure of the dry-well, up to 67% of the tellurium and 21% of the cesium and iodine could be re-leased. The worst-case BWR accidents in Wash-1400 predicted 40% of the cesium and iodine would be released and 70% of the tellurium in one set of sequences, and 90% of the iodine, 50% of the cesium and 30% of the tellurium in another set.

SUMMARY OF RELEASE FRACTIONS FOR A SEQUOYAH UNIT

Sequence	Species	Fraction of inventory released	Wash-1400 release fraction
TMLB $'\gamma$	I	1.7×10^{-2}	0.7 to 0.2
	Cs	2.2×10^{-2}	0.5 to 0.2
	Te	1.4×10^{-2}	0.3 to 0.3
TMLB δ	I	3.9×10^{-4}	0.7 to 0.2
	Cs	4.4×10^{-4}	0.5 to 0.2
	Te	2.2×10^{-3}	0.3 to 0.3
$S_2HF\gamma$	I	6.0×10^{-3}	0.7
	Cs	6.0×10^{-3}	0.5
	Te	2.9×10^{-2}	0.3
TMLγ	I	1.3×10^{-3}	0.2
	Cs	6.5×10^{-3}	0.2
	Te	5.5×10^{-3}	0.3
TMLδ	I	6.9×10^{-9}	3×10^{-2}
	Cs	7.4×10^{-9}	9×10^{-3}
	Te	1.6×10^{-8}	5×10^{-3}

Those early BWR drafts said further analysis of structures at individual BWRs could affect their conclusions. For instance, the Peach Bottom report said, "If the reactor building were expected to withstand blowdown forces from the failure of primary containment with a high degree of confidence, the risk could be reduced substantially." The Grand Gulf draft suggested some Mark I reactor buildings could retain more fission products than this Mark III, because of the "limited strength" of Grand Gulf's shield building and the lower capacity of its standby gas treatment system.

Researchers on all sides say there are major uncertainties left in all the analyses, despite the advances made in the last several years. Participants in the Idcor program have expressed some frustration in two technical meetings because NRC research has occasionally produced data outdating their analyses by the time they report it. But Idcor researchers have come up with one finding that has NRC contractors going back to their models for a new look. After Idcor and NRC researchers met in Baltimore Feb. 7-8, Idcor researchers reported that in their computer code, fission products that settle on the surfaces inside the reactor continue to produce heat through fission decay. Under some circumstances, they said, that heat could be sufficient to resuspend the particles as aerosols, increasing the fission product aerosol inventory at times not previously accounted for. Timing is a key question, since all releases to the environment depend on what is in the reactor atmosphere at the time that a leak path develops to the outside.

NRC researchers agreed that their codes, considered generally more complex than Idcor's, do not account for resuspension of aerosols and said they want to look at the effect of that phenomenon on both their thermal-hydraulic and fission product transport codes. It is uncertain what differences the phenomenon could make since Idcor has not given its plant-specific analyses to NRC with the work on core heat-up and on fission product transport phenomena. Core heat-up, including steam and hydrogen production that can endanger the containment, were debated by NRC and Idcor technical experts at Harpers Ferry, W. Va. late last year and there were few substantial areas of disagreement (INRC, 12 Dec. '83, 6). But at the Baltimore meeting, Idcor speakers said their calcula-

SUMMARY OF RELEASE FRACTIONS FOR A ZION UNIT

Sequence	Species	Fraction of inventory released	Wash-1400 release fraction
TMLB $'$	I	1.9×10^{-6}	8×10^{-4}
	Cs	1.9×10^{-6}	8×10^{-4}
	Te	7.8×10^{-5}	1×10^{-3}
$S_2D\epsilon$ (Hot Leg)	I	2.5×10^{-8}	8×10^{-4}
	Cs	2.3×10^{-8}	8×10^{-4}
	Te	3.6×10^{-8}	1×10^{-3}

tions of potential fission product releases were coming in higher, in some cases, than the Battelle draft numbers, and sources said the resuspension phenomenon was apparently a major contributor. The meeting on the plant-specific analyses, once set for March, has now been moved back to May because both sides want to do more work.

The major disagreements between Idcor and NRC contractors identified at the Baltimore meeting included:

- **The timing of tellurium releases.** Idcor experts think tellurium will be released earlier than NRC's experts, who say some tellurium will be temporarily retained by unoxidized zirconium cladding. Both sides agreed Idcor's model called for release of other fission products at lower temperatures – earlier – than research now indicates the release will occur.

- **Whether there is silver in the aerosols.** NRC analysis of contamination in the Three Mile Island-2 reactor indicates a significant portion of the aerosol mass was silver from the control rods. Idcor's models show the silver melting and running off before there is significant vaporization. Paul Nakayama of Jaycor Corp., an Idcor contractor, said he has been unable to figure a way for the silver to be available for aerosol formation, given the temperatures and pressures at core melt. Mike Kuhlman of Battelle said silver could represent almost half the aerosol mass, and Phil McDonald of EG&G Idaho, an NRC contractor, said the aerosol quantity and the timing of its formation could make a big difference in the amount of fission products carried out of a damaged reactor vessel.

- **Distributions of different sizes of particles in vapors.** Idcor's model assumes a more uniform distribution than those used by NRC's contractors. Since the particle size – measured in microns – is directly related to how long the particle stays suspended in vapors and available for release, assumptions about size can affect results throughout calculations for fission product transport, through both the reactor coolant system and the containment.

- **Use of a constant decontamination favor (DF)** for suppression pool scrubbing in BWRs. Idcor and General Electric experts said they had used the most conservative factor in their calculations, and that tests showed the suppression pool could be expected to scrub out fission products much more effectively. NRC contractors questioned whether the DF should be altered over time, as temperatures increase and as the suppression pool fills with debris.

NRC contractors acknowledged that they have found some phenomena more completely modeled by Idcor's codes than by NRC's. Several observers said Idcor's work was winning "more respect" from NRC for tackling such phenomena. However, sources on both sides predict "blood on the floor" for the May meeting when Idcor's application of its codes to specific plants go head-to-head with the Battelle analyses done for NRC. Idcor has not released its studies, and some elements are being reviewed, but Idcor announced last fall that the studies showed all U.S. nuclear plants could withstand severe accidents safely.

Industry has been hoping the source term research would both stave off severe accident backfits by proving current plants are safe enough, and provide some basis for reducing emergency planning requirements by showing the worst accidents have far less severe consequences than Wash-1400 predicted. The draft studies done by Battelle and Idcor must be combined with other studies by NRC before their exact effects will be known. One group in NRC is looking at the probability of each accident sequence, to see if the risk of the worst sequences occurring is a real one. Two other groups are looking at containment behavior to ascertain how real the risk of each type of containment failure is. No group has completed its work.

Battelle tested codes on two PWRs with large, dry containments, Surry and Commonwealth Edison's Zion. Both plants have had probabilistic risk assessments (PRAs) and NRC's contractors took sequences that ranked high on their PRAs' risk lists to test their codes. According to drafts given to NRC in January, both were analyzed for the 'ε sequence – station blackout with failure of the secondary system relief valves that cannot be corrected before the core melts through the containment. Researchers estimated there would be substantially more "scavenging" of fission products by the reactor coolant system in the Zion case than at Surry, with fission product releases more than 100 times lower than predicted in Wash-100. At Surry, however, the numbers are slightly higher than the Wash-1400 predictions, with less than 1% of the cesium and iodine available by the time containment is breached but some 7.9% of the tellurium available. At Surry, the same sequence with an early containment failure due to overpressurization, TMLB 'δ, was calculated, and the results were far lower than Wash-1400. Instead of 70% of the iodine, 50% of the cesium and 30% of the tellurium escaping to the atmosphere, the researchers now estimate only 4-5% of the iodine and cesium and 11% of the tellurium would escape the reactor coolant system and containment, even with the early containment breach. Early breaches are generally considered the most serious accidents, though there is debate about when and how such breaches could occur in reality.

Other accident sequences analyzed, with all showing significant reductions in expected releases, include:

AB, a hot leg loca followed by failure of all engineered safety features, combined with ϵ (melt-through), γ (failure by hydrogen burn), and β (failure by inadequate isolation) containment failure modes; S_2D, a small-break loca with an emergency core cooling injection failure, analyzed with the γ and ϵ failure modes.

Sequoyah, chosen to represent ice-condenser containment PWRs, was analyzed for the TMLB sequence with γ and δ containment failures. The latter is a failure by overpressurization and was postulated to take place almost seven hours later than the γ failure, estimated to occur about 3.5 hours into the accident. Also analyzed at Sequoyah were: the TML sequence, an initiating transient followed by failure of the diesel generators, secondary system relief valves and auxiliary feedwater, for both the γ and δ containment failure modes; and the S_2HF γ sequence, a small-break loca with failure of the emergency core cooling system and containment sprays leading to containment failure from a hydrogen burn. In all cases at Sequoyah, releases were substantially below the Wash-1400 predictions, with the ice and its compartment structures estimated to catch anywhere from 6% to 25% of various fission products, though the reactor coolant system retained the bulk of those containments as it did at the other PWRs. – *Margaret Ryan*

IHSI MAY REMEDY CRACKING PROBLEMS AT SOME BWRS, NRC STAFF SAYS

Induction heating stress improvement (IHSI) "may provide an acceptable remedy for long-term operation" of BWRs that do not have "significant" primary system cracks, the NRC staff told the commissioners last week in an update on long-range planning for resolving the problem of intergranular stress corrosion cracking (IGSCC). The staff said it will have specific recommendations for guiding utilities in adopting long-range strategies by May, but it noted that several utilities are "actively considering" pipe replacement.

The staff plans to be able to "anticipate all likely long-term solutions" that BWR owners may propose, the staff said, so that it can readily determine the "acceptability and conditions which might accompany acceptability" of those proposals. One potential conflict the staff foresees with industry is over deciding how remedial techniques such as IHSI will impact inspection frequency and radiation exposure to inspectors over the lifetime of a plant. To expedite resolution of such conflicts, the staff, in conjunction with outside consultants, is developing specific policy positions on:

– replacement of all or part of susceptible piping;
– IHSI of piping for recently licensed plants;
– IHSI of piping for older plants where cracking has not been detected;
– use of hydrogen injection techniques in combination with other mitigation measures;
– long-term operation with shallow cracks and/or crack repairs; and
– combinations of the above approaches on a plant-specific basis.

Meanwhile, at a recent, closed meeting of the Organization for Economic Cooperation & Development (OECD) Nuclear Energy Agency in Paris, there appeared to be international agreement that IGSCC is a "safety-relevant" problem with only one certain solution – pipe replacement. However, sources said, none of the nuclear regulators said they favor such a radical policy. Rather, regulators worldwide are grappling with the problem of deciding which of several short-term solutions should be adopted. Sources said that no regulatory body has yet taken a firm position on this issue. At the meeting – the first concrete follow-up to OECD's caucus last June of senior regulatory officials – U.S., Japanese, Swedish, West German, Italian, Finnish, Swiss and Spanish officials gave formal presentations. Representatives from the United Kingdom, France, Norway and Holland also attended.

The participants in the Paris meeting were told that worldwide about 10,000 BWR welds – or some 10 kilometers of welding – are susceptible to IGSCC, sources said. It is estimated that a maximum of 25% of those welds actually are affected by stress corrosion cracking. The most conservative repair, a sweeping change of all BWR pipes, would cost $50-million per unit, excluding outage time, sources said. If regulators are willing to accept a less-than-perfect solution, they are faced with the necessity of deciding what size cracks are acceptable and how to reliably detect and measure them.

So far, the sources said, only the Japanese appear to have taken a position, albeit informal, on the question of what size cracks should trigger repair or replacement of BWR piping. Japanese regulators reported that they are working to a "rule of thumb" under which cracks reaching one-third of the pipe wall thickness would trigger a regulatory response, the sources said. However, the regulators stressed that they are treating each plant individually. In the 1970s, German utilities were ordered to change BWR piping, but for a different reason (a cold cracking problem stemming from steel manufacture), with the result that German BWRs have not been affected by IGSCC. Sources noted that other regulatory bodies appear to be waiting to see what the U.S. plans to do.

Participants reported that the "big hit" of the meeting was IHSI, which involves heating welds from the outside via electric coils while cooling water moves through the pipe, thereby reversing the stress in the weld. This technique has been used in the U.S., where General Electric has been competing with Japan's Ishi-

INTER-DEPARTMENT MEMO - PUBLIC SERVICE COMPANY OF COLORADO

PPC-84-0693

DATE: March 14, 1984

TO: Mr. LeRoy W. Singleton, Superintendent of QA Operations, FSV

FROM: Jerry J. McCauley, Results Engineering Supervisor, FSV

ATTN:

SUBJ: CAAR 233

The target date for our completion of CAAR 233, concerning the incorporation of relay settings and tolerances into the Master Setpoint List, is August 15, 1984.

Jerry J. McCauley

Jerry J. McCauley

JJM/djc