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COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

Prairie Island Subcommittee Meeting

Room 1046
1717 H. Street, N.W.
Washington, D. C.

Saturday, 31 March 1973

The meeting was convened at 9:30 a.m., Dr. W. Kerr, presiding.

IN ATTENDANCE:

The Board:

H. S. Isbin
W. R. Stratton
W. Kerr
J. E. Hard

Northern States Power:

M. N. Bjeldanes
A. V. Dienhart
R. J. Jensen
W. J. Jokela
G. H. Neils
C. J. Ross
C. T. Tice
F. P. Tierney
E. L. Watzl

Pioneer:

E. U. Clausen
H. S. Dryer
R. A. Dudek
W. M. Gelsyzinnus

D. E. Hanson
C. E. Hean
A. F. Kitz
M. P. Lin
V. Musial
E. J. Prahian
D. E. Sahlin
Charles Agan

Regulatory Staff:

R. D. DeYoung
R. W. Klecker
L. L. Kintner
C. G. Long
R. R. Maccary
D. K. Olson

Westinghouse:

R. H. Balwanz
F. M. Bordelon
D. W. Call
J. O. Cermak
D. G. Christenson
H. M. Ferrari
R. L. Hofer
J. S. Moore
E. T. Murphy
C. E. Rossi
R. Salvatori
J. R. Santoro
S. N. Ehrenpreis

Teledyne:

D. Landers

Nuclear Service Corporation:

R. Keever

Shaw-Pittman

B. Churchill

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If there aren't any questions, I will continue on to the next item of the agenda.

DR. ISBIN: Has the public hearing date been set yet?

MR. JENSEN: No, it has not.

DR. ISBIN: Was there a prehearing conference?

MR. JENSEN: There has not been a prehearing conference. There have been discussiong of having one on April 11. I am not sure just where that stands now, if it is set for April 11.

DR. KERR: Insofar as you can predict, how far behi Unit 1 is Unit 2?

MR. JENSEN: A little less than a year. It looks n like Unit 2 will be ready for fuel load about May 1 of 1974.

DR. KERR: Thank you.

MR. JENSEN: The next item we want to discuss with you this morning is the high energy line break and our modifications. This will be presented by a member of Pioneer Service and I would like to just give a brief summary of where we are now and how we got here.

During the ACRS meeting on October 27, members of the ACRS raised questions concerning a rupture of the high energy lines outside the containment. Following this, we reviewed the design and our design phases and responded to the AEC Staff by a letter of November 6, 1972.

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Following this, the Staff concluded that certain changes would be required at Prairie Island and we received design criteria clarification from the Staff dated -- in letters dated December 12, 1972, and January 11, 1973.

In response to questions by the Staff, we submitted Amendments 25, 28, 29, and 31 describing the proposed modifications to meet these criteria. In general, the criteria require protection of equipment necessary to shut down the reactor and maintain it in a safe shutdown condition, assuming a concurrent and non-related single active failure of protective equipment should be provided from all effects resulting from ruptures in pipes carrying high energy fluid up to and including a double-ended rupture of such pipes.

The rupture effects on equipment to be considered include pipe web, structural and environmental effects, the locations of these breaks are to be postulated to occur at locations specified in the pipe whip criteria.

A high energy fluid is defined as one which exceeds temperature and pressure, conditions of 200 degrees Fahrenheit, and 275 psig, respectively.

The pipe whip criteria defines postulated rupture locations at each piping run or branch run to be at, one, the terminal ends; two, any intermediate locations where stresses exceed .8 of S of H, plus S of A, and, three,

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additional intermediate locations selected on a reasonable basis. These additional locations are selected on the basis of highest stress points, remaining highest stress points. It is a minimum; there are -- it would be two intermediate locations selected in each piping run.

In addition, similar protection of equipment is required from the effects of a postulated single open crack anywhere on a pipe carrying high energy fluid. The size of the postulated crack is to be assumed to be one-half of the pipe diameter times one-half of the wall thickness. Now we are providing protection from the above postulated events by several different methods.

In summary form, they are as follows: one, pipe restraints; two, relocation of some of the required equipment; three, isolation of certain volumes of the high energy lines; four, encapsulation speeds at certain locations on high energy lines to limit the flow of steam or water of a pipe break; and, five, impingement barriers to control the direction of the jet generated from a pipe break; and, six, analysis and qualification of required equipment exposed to adverse environmental conditions in order to prove their capability to perform.

Now, in addition to the above modifications, we will conduct preservice and in-service inspection of pressure retaining wells in the high energy piping which are not encapsulated within the auxiliary building in accordance with the ASME, Section 11 Code, except that we will inspect 100 percent of the accessible code inspectable wells during an inspection interval rather than the code-required 50 percent.

We will perform a design analysis of the proposed modifications, including a dynamic analysis of the piping systems, which will provide adequate assurance of the capability to bring the plant to a cold shutdown condition within a reasonable time following the postulated rupture of any pipe carrying a high energy fluid outside of containment.

At this point, I would like to turn the presentation over to Mr. Charles A. Agan of Pioneer Service for a more detailed presentation.

(Slide.)

MR. AGAN: The handouts I have given you this morning are reproductions of figures that already appear in the amendments submitted to the FSAR, namely 28, 29, and 31.

Some of them I will be showing in the overhead slides themselves.

As stated in Mr. Giambusso's letter of 1972, the criteria for a high energy system is as follows:

The service temperature must be greater than 200 degrees and the design pressure must be greater than 275 psig. A complete survey of all the piping systems, including design class one, two, and three, throughout the plant was made and those systems -- throughout the plant were made, and those systems that met the criteria were tabulated. Each of these systems was then examined for physical location and proximity to the plant class one areas. Only those systems that are routed through within or adjacent to the class one areas that are normally operating systems, were considered for subsequent examination.

You see the five systems that meet the criteria listed here. They are main steam, feed water, the chemical, and volume control system let-down, steam generator blowdown, and steam to the auxiliary feed water pump turbine.

Each of these systems was then examined and a stress plot for each piping system was developed.

I have a typical stress plot that you have in your handouts.

(Slide.)

This happens to be for the main steam piping system and it plots piping stress against distance along these piping runs.

The pipe break location criteria, as stated in Mr. Giambusso's letter was then applied and large break locations identified. These include the terminal ends, and the points of high stress. In addition the criteria for the critical crack was applied. This is the one and a half diameter of one-half the wall thickness. These break locations were then identified on a piping isometric for each of the high energy systems.

Again, you have these in your handouts.

Again, this is a piping isometric of the main steam system showing our two steam generators and the piping run going over to the turbine and the services in the turbine building. We applied the criteria and then spotted them on the piping system. In addition, we located the main steam piping by compartment in the auxiliary building, transposing the piping runs you saw in the previous diagram as it traverses its way through the auxiliary building out into the turbine building by various alterations.

An investigation was then made to determine what the minimum amount of equipment would be required to mitigate the consequences of the postulated pipe ruptures you have just seen and subsequently place both units in a cold shutdown condition. The list of equipment was to be determined on the basis of a concurrent loss of off-site power and a single active failure of any component. These lists were included in Amendment No. 31 to assure that under all postulated breaks, both large and small, that the reactor will be tripped, concentrated boric acid will be added to the reactor cooling system, and a heat sink provided for the heat to escape from the core.

In addition, a way for the heat to go from the cold shutdown has been provided.

Each compartment shown here in the auxiliary building was then examined for the pressure and temperature resulting from the postulated breaks in that compartment or in adjacent compartments.

I have some typical curves which again you have in your handout.

(Slide.)

For one -- the smaller compartment in the south side of the plant, which plots pressure against time after the postulated breaks. A modified version of it was used to determine the environmental conditions in each of the compartments. I might add that the conservatism of our calculations was verified by an independent calculation performed by the AEC Staff.

The calculations, for the net physical volume of the compartments in existing vent areas, stairwells, grading, and corridors --

DR. KERR: Did you say the "conservativeness" of your calculations or the accuracy of your calculations?

(Laughter.)

MR. AGAN: Both.

DR. STRATTON: The accuracy of doing it in a conservative manner was verified.

MR. AGAN: Yes, sir.

After the compartment accident parameters were determined, they were compared with the structural capability under the accident conditions which include dead load, live load, the design basis, earthquake load, jet impingement load, if applicable; pressure load, and the restraint reaction load.

Wherever the structural capability was exceeded or the environment was undesirable, modifications were provided.

I'll describe these modifications in more detail with some other slides.

I might also mention that the addition of encapsulation sleeves to the main steam line in compartments X and Y, which the the smaller compartments -- this is the pressure curve for those compartments --

(Slide.)

-- these are the two small compartments where our No. 11 steam generator exit containment of them go through the auxiliary building; and some recent calculations show that the blow-out panels and the new wall that we have described in our submittal may not be required at this time.

Each piece of the equipment listed on our required list, including their power supplies, breakers, cables, cable trays, conduit, et cetera, then were compared to the location of the postulated breaks and the general environmental conditions. Wherever a piece of required equipment was vulnerable to the effects of a postulated pipe rupture, either the wing, jet impingement or the environment, physical protection or physical relocation was provided.

All remaining equipment in the steam area environment has been or will be qualified by tests.

Each of the high energy systems under discussion, the five, were examined in accordance with the pipe whip criteria stated in Mr. Giambusso's letter, and wherever a plastic hinge could form, allowing the pipe to whip, rupture restraints are provided if the whipping pipe could adversely affect any structure system or component required for that accident.

The blowdown forces used in our calculations were determined utilizing after-version of the widely-known AEC-sponsored RELAP-3 Computer Program, which computes a force-time history curve with the reaction loads resulting from the postulated breaks for either vapor, liquid, or two-phase flow.

In addition, a detailed nonlineal elastic plastic analysis is being performed to confirm the conservative calculations utilized in our design.

The AEC Staff haspublished a tentative criteria for the design of the encapsulation sleeves and impingement barriers we intend to use. The encapsulation sleeves are provided to either restrict flow from the break or to limit the compartment pressurization. Impingement barriers are provided for physical protection from the jet effects of the break.

Encapsulation sleeves are to be designed to the stress limits of ACME Section 3 for component Class-2 components, and are constructed in accordance with the rules of ACNIP-37 Class 2 components.

In addition the rules of ASME for this service selection are being applied to all high energy systems as stated by Mr. Jensen.

The fluid flow model used in the pipe rupture inpingement pressure program to give us our forces from the jet is based on the work published by S. J. Judy on two-phase critical flow and jet forces. His correlations have been substantiated in each instance by numerous sets of data.

DR. ISBIN: Discharge coefficient of one?

MR. AGAN: I will have to -- Tony Kitz, from our Analytical Department says Yes.

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I would like to show you come of the modifications we have proposed and are designing for Prarie Island.

(Slide.)

This is typical of our relief valve, safety valve headers, our main steam piping running down here and we have a 30-inch riser up to our safety valve and relief valve header.

One of the break locations is at this T connection so it will preclude this riser and header from becoming a missile and also opening up a single 30-inch break.

We propose a header restraint system of tie rods to hold this in place as well as encapsulate the T and the vertical section; so, your net release area will be just the annular area between our encapsulation sleeve and the pipe.

We use this on our atmospheric steam dump headers as well, the only difference being the number of headers on the valve.

DR. ISBIN: This encapsulation sleeve, could you explain it a little better for me?

MR. AGAN: What you have in the piping run is a standard T with a riser. What we are putting over that T is a slightly oversized T with a guard type pipe around the existing pipe; and then with this saddle, and this saddle, to hold it from vertical movement after the break and also to limit flow through this annulus area between the inner and outer pipes.

DR. STRATTON: Is this guard pipe welded to the steam line?

MR. AGAN: No, none of our modifications entail attachments to the existing system.

DR. STRATTON: The complete guard pipe and saddle arrangement is supported independently of the steam line and the riser there?

MR. AGAN: In some cases they will be; in others we may beef up the existing hanger systems to take the additional load. They will act independently of the pipe. They are not physically attached to it. There is a gap between them to allow for thermal movement of the existing main steam pipe.

At no time in any of these modifications are we welded to an existing piping system.

(Slide.)

This is a typical impingement barrier where in particular number 12 steam generator exits containment in the shield building on the mezzanine floor. We will be surrounding it, if you will, with an impingement barrier. There is some electrical equipment in the area that we do need on our required list, so we are providing this similar type sleeve strictly for impingement protection in this compartment and I have shown this one because there are several appurtenances to the existing pipe.

Now we will, in this case, put a stub around them and leave these open in a direction as long as there is nothing in that direction that could be adversely affected.

These will be fabricated in either halves or quarters, put around the pipe rim to your preform insulation, again without attachment to the piping system.

(Slide.)

This is another example of a -- this is the T with the riser going up to our safety valve header and this does not show the restraint in design. We have also on our operating floor -- there is some electrical switch gear right here; several appurtenances including a hanger on the existing piping which we will leave cut out or put stubs on providing that no steam will impinge on any of our required equipment. The compartments have been analyzed for these breaks and break areas.

Again these will not be welded together to restrict the movement of the existing steam line in any way.

(Slide.)

There is one other type device we are using and this is at the turbine building, auxiliary building interface. We have a break here, circumferential and longitudinal split. We have encapsulated it.

And to preclude movement of the sleeve, we have put a ring here so that the sleeve itself will not move down the piping system opening the break to the room.

All of these devices are hinged some way so that they remain in place and the piping system is restrained so it will not pull out of any of the breaks in the areas we are required to have protection in.

As I mentioned, these are just typical modifications we have designed for Prairie Island and I will open it up for any questions you might have on our proposed design.

DR. KERR: I have none.

DR. ISBIN: Are these devices or sleeves or whatever you call them, have they been used in any other application?

MR. AGAN: Not for the high energy piping systems we are talking about.

DR. ISBIN: This is a first application?

MR. AGAR: They have been used in places around hydrogen pipelines, for one, to preclude leakage into rooms in case the hydrogen pipe leaked, things like that. It is not a new concept.

Guard pipes have been used, but I don't know of any steam lines that are guard-piped.

DR. STRATTON: How many feeder lines do you feel you have protected one way or the other?

MR. AGAN: About 50 linear feet plus about -- four Ts and four of the elbows.

DR. STRATTON: What fractional amount?

MR. AGAN: Of the total amount in the auxiliary building?

DR. STRATTON: Half the line, a third of the line, quarter of the line, ten percent?

MR. AGAN: I would guess in the auxiliary building it would be between 25 and 50 percent. It is a significant amount in the auxiliary building.

DR. KERR: Don't you in effect have guard piping around your main steam lines when it --

MR. AGAN: Through the annulus between containment and the chute, yes.

DR. KERR: Okay.

DR. STRATTON: There are two ways to attack the problem, a safety problem raised by us. This is a good example. You can devise the protection which is this, which you have done. I assume that it has been examined -- the concept has been examined by the staff and is satisfactory, looks all right to me. I am not really competent to judge.

The other way to attack it is to examine the probability of this happening and given a happening, what's the probability that significant things would be damaged that would impede shutdown; and this is really the second way to do it, to get at it.

The probability is sufficiently small, if it is, we can look differently at the required protection than if the probability is high.

I addressed this question to the staff and had Pioneer look at this question, had Pioneer examine the probability of this --

MR. AGAN: I will confirm what Mr. Kintner said. We know of no pipe systems.

DR. STRATTON: That's not quite good enough. Have you ever had an estimate of the pipe years of operation, so to speak?

MR. DRYER: Mr. Larry Newhart of Pioneer has submitted to the staff in a letter a complete examination of the probability of this particular type happening and the conclusion there was that the probability of this happening is something like ten to the minus ten, a very sort of a loose -- and if we put in conservativism, it would be somewhere less than ten to the minus seven, in other words, an absolute zero of top limit is ten to the minus seven. The most probable fact would be ten to the minus ten.

DR. STRATTON: I think the question is answered in that you have examined --

MR. DRYER: The answer is yes.

DR. STRATTON: You wrote a letter to the staff giving this information?

MR. DRYER: That's correct.

DR. STRATTON: Do we have this letter? I confess I don't always read everything.

MR. KINTNER: Yes, we have the report which Larry Newhart of Pioneer prepared and this is filed in the document room.

DR. STRATTON: Do we have it?

MR. KINTNER: Yes, you should have it. If you don't, I can get it to you.

DR. STRATTON: Do we have it?

Okay, thank you.

MR. DIENHART: Could I make a pertinent comment in response to your --

DR. KERR: May I ask one clarifying question.

You said ten to the minus seven. Ten to the minus seven per what, per year, per life of the plant?

MR. DRYER: Reactor year.

DR. KERR: Thank you.

DR. STRATTON: Thank you.

MR. DIENHART: Arthur Dienhart of NSP.

When the question of protection against high energy piping breaks outside of containment was raised by the staff last fall, NSP was asked to give its views on this type of accident and why it hadn't been considered prior to last fall; and our response in a meeting with the staff, Dr. Hendry and other members of the staff, was that our experience in conventional thermal power plants and the experience of the industry as recorded in the literature and on the bases of our general knowledge of happenings in the industry, led us to conclude that the probability of this kind of accident was extremely remote. No one that we had any contact with in the industry had ever been aware of any kind of catastrophic failure of a main steam pipe or a boiler feed pipe which was built to quality requirements of the type that are being called for in a nuclear power plant.

We obviously had no way of making a complete survey of the universe and we could not document this with precise numbers; but our position was then, and still is, that this is an accident with an extremely low likelihood of probability.

Obviously, since the staff has concluded that protection must be provided, and in order to keep our project moving, we have agreed to provide the kind of protection that Mr. Agan has just described to you. But we still are of the opinion that this is providing protection for an extremely improbable event.

DR. STRATTON: Thank you.

DR. KERR: Are you through with your presentation?

It has been suggested that a ten-minute break at this point might be in order. I declare a ten-minute recess.

(Recess.)

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DR. KERR: Our present schedule calls for lunch at 12:30 for an hour, and I see no reason for leaving that schedule.

Who is next on the scheduled presentations?

MR. JENSEN: Before we go to the next item I would like to reiterate what Mr. Agan said that the handout material he had and that which is shown in the slides is part of the public record and has been submitted in our amendments on the modification.

The next item that we have for presentation is the fuel densification question, and Dr. Ferrari of Westinghouse will make that presentation.

DR. FERRARI: My name is Ferrari. I am Manager of Fuel Licensing for Westinghouse.

Fuel densification under radiation undoubtedly occurs through greater or lesser extent in all commercial oxide fuel. The importance of this phenomenon wasn't fully appreciated until after the fuel densification collapse observations in a reactor.

Fuel densification results in the slinkage of the UO_2 pellet in both actual directions and in a radial direction. The extent of fuel densification is shown in my first slide.

(Slide.)

Here we have plotted the change in fuel stacking which is a measure of fuel densification, a function of