July 26, 1967

To : ACRS Members ORIGINAL SIGNED BY M. W. LIBARKIN

From : M. W. Libarkin, Staff Assistant

Subject: MEETING TO DISCUSS CRITERION ON ACCESSIBILITY FOR INSPECTION OF REACTOR PRESSURE VESSELS, JULY 19, 1967

Enclosed for your information is a record of the subject meeting. Comments are invited from those who attended.

Chap 7
FN 29

Enclosure:

Notes of Meeting to Discuss Criterion on Accessibility for Inspection of Reactor Pressure Vessels

ACRS Job 429 Box 4 Shelf 11914
Correspondence 7/67

MWL/jf

REG./ACRS MEETING WITH REACTOR VENDORS
TO DISCUSS ACCESSIBILITY FOR INSPECTION
OF REACTOR PRESSURE VESSELS

July 19, 1967

The meeting was held to discuss with the power reactor vendors, the proposed criteria on accessibility of pressure vessels.

Attendees:

Westinghouse

G. Landerman
L. Katz
E. S. Beckjord
H. D. Greenberg (R&DC)

Babcock & Wilcox

J. H. MacMillan
D. K. Davies

GE-APED

W. Schultheis
W. R. Smith, Jr.
J. B. Graham
A. M. Hubbard
O. H. Creager

Combustion Engineering

R. E. Lorentz, Jr.
J. M. West
C. Givons

DRS

E. G. Case
A. B. Holt
R. R. Maccary

DRL

P. Morris
S. S. Pawlicki
D. Thompson

DRD&T

F. R. Cook
L. E. Alsoger
J. L. Marshon
T. G. Schleiter
I. E. Jackson
M. Booth

Compliance

C. W. Reinmuth
L. Kornblith

AEC-REG

C. Beck
M. M. Mann

ACRS

N. J. Palladino
D. Okrent
H. Etherington
S. H. Bush
M. W. Libarkin, Staff

A. EXECUTIVE SESSION

The Committee members and members of the Regulatory Staff met in executive session to discuss the procedures for the meeting. Mr. Case noted that a tentative agenda had been distributed to each of the companies invited indicating what matters would be dealt with. In answer to Mr. Mangelsdorf, Mr. Case commented on some of the reactions which he has received to the criteria for accessibility. B&W has indicated that they have already met the criterion in their design for the Lake Power Company. He felt that General Electric would probably offer some resistence since in the GE designs it is most difficult to remove the core internals and the company sees no gain in terms of relaxed requirements elsewhere.

Mr. Case also noted that the letter had indicated that a meeting in private could be arranged if any of the vendors so wished. Thus far, Mr. McWhorter has indicated that GE might want to have such a private discussion.

Mr. Case thought that it was possible that representatives of one or more utilities might appear since the meeting had been announced in Nucleonics Week. It was agreed by those present that utility representatives would not be invited to attend this meeting. Mr. Case also commented that representatives of Nucleonics Week had been told they would not be invited but that he had agreed to inform them as to what had taken place.

The discussion then turned to anticipation of questions which might arise and of suggested approaches to these. It was agreed that if the degree of inspection which is being considered came into question the document now under preparation which is to form part of the AEC requirements for quality assurance of reactor pressure vessels could be discussed in a general way. Mr. Case added that while access to the entire vessel is being required a more frequent inspection of so called critical areas would probably be in order in his opinion.

Mr. Case noted that if the question arose as to what standard would be used to validate the inspection it might prove embarrassing since none is presently available. Mr. Etherington suggested, however, that what was being requested at this time was the capability of performing inspections in anticipation of the development of appropriate techniques.

Mr. Palladino suggested that those present might also consider that the vendors would suggest that designing for inspectability could lead to reduced safety since compromises would then be made on the strength of core internals, etc.

Other comments included one by Dr. Okrent to the effect that there might be some reason for performing more inspection than is thought strictly necessary in order to establish how much is indeed sufficient. Perhaps some owners could perform 100% inspections and if expectations are confirmed future programs could be reduced.

Mr. Reinmuth commented that when ultrasonic tests are performed during fabrication there are some flaws which are considered recordable but which are not necessarily repaired. The Regulatory Staff has been pressing for good documentation of these so that future in-service inspections could reveal growth, etc.

B. MEETING WITH REACTOR VENDORS

Mr. Case opened the meeting by observing that the Commission is presently considering the establishment of the criteria listed in Mr. Price's letter and it was thought desirable to get some feeling for the problems which might be raised by these criteria in terms of redesign, etc.

Mr. Case suggested that the first of the two criteria be discussed initially:

> "The interior of the reactor pressure vessel, including the bottom head, should be accessible for visual observations at appropriate intervals. Such observations would have as their objective detection of mechanical damage or structural failure of the reactor vessel and its internals."

Mr. Maccary then listed the objectives of the visual inspection criterion.

1. Examinations of vessel interior surfaces to discover evidence of mechanical damage, unanticipated erosion in local areas, corrosive effects of long-term exposure to reactor coolant, gross cracking at areas subject to complex thermal gradients or shock.

2. Detection of any major structural damage of core support attachments to the vessel from unexpected vibratory or dynamic loads imposed during extended service periods.

3. Examination of the reactor internals to uncover any evidence of damage induced by flow and hydraulic loadings during operation, disassembly or distortion of core components from excessive thermal loads, wear and breakage of fasteners in the core structure caused by vibrations.

Mr. Maccary stressed throughout this list that long-term effects were of interest and added to the list long-term surface changes, that is changes to the cladding from presently unanticipated effects.

Mr. Case noted that there was also interest in determining the existence of damage or changes to other components within the vessel such as parts of the ECCS.

Mr. Katz replied that the Westinghouse Corp. has given careful consideration in their designs so that it possible to inspect the following:

1. The entire surface of the reactor vessel
2. The inner and outer surfaces of the vessel closure head
3. The vessel studs, nuts and washers
4. The field welds connecting the vessel and primary piping
5. The reactor internals
6. The vessel and closure head, flange and gasket sealing surfaces, fuel assembly and control rod clusters

The following provisions have been made to allow these inspections.

All internals are completely removable during refueling; tools and storage space are provided at each facility.

The closure head can be stored dry on the reactor operating deck.

Vessel studs, nuts and washers are stored dry during refueling operations.

Removable plugs are provided in the shield concrete above the coolant piping-to-vessel weld.

Access holes in the lower internal barrel flange allow inspection of lower internal structure without removal of the core barrel.

A removable plug is located in the lower core support plate to allow access to the bottom head inner surface with the core support plate in place.

The control rod cluster changeout station design allows visual inspection of fuel assemblies and associated controlrod clusters.

Mr. Katz concluded that the present Westinghouse designs provide maximum flexibility and accessibility for inspection and that no design changes would be necessary to allow these designs to meet the proposed criterion. Mr. Case asked how much time would be necessary for removal and installtion of core internals to allow access to the entire inner vessel surface. Mr. Katz suggested that it might require one week for removal and one week for reinstallation based on past experience.

Mr. Case asked if present inspection techniques were thought to be adequate. Mr. Kats replied that Westinghouse has had considerable success with borescope and underwater TV inspections. In addition, he noted that a satisfactory inspectionscan be performed using strong light and binoculars.

Dr. Bush asked if the external surface of the vessel was accessible as well. Mr. Kats replied that presently there is not access to the external surface of the reactor vessel in the area of the primary concrete since the insullation is intimately attached to the vessel. The bottom head and flange area are accessible, however.

Mr. Palladino asked if the inspection would be done with the vessel wet or dry. Mr. Kats noted that the core internals would be submerged unless they were removed but the top of the core would be under only about one foot of water. It is presently thought to be impossible to inspect a dry vessel visually because of the radiation problem even with the core internals removed and in storage. Mr. Etherington asked if it would be possible to sum up by saying that the present design already complies with criterion 1. Mr. Kats thought this would be a fair statement.

Mr. Palladino noted that Mr. Kats had referred to past experience and asked what the results of past visual inspections had been. Mr. Kats answered that clean, bright surfaces had been seen on all except horizontal parallel surfaces of plates and on some parts of the bottom head. No special crud cleaning techniques have been necessary. Dr. Mann asked what resolution was possible with the visual inspection techniques now available. Mr. Kats thought that the inspections which had been performed by Westinghouse personnel would uncover gross cladding cracks, that is areas approximately three inches in diameter, but would not discover hairline cracks. He suggested that a 1/4-inch cladding crack would represent a marginal situation in terms of the resolution possible.

Mr. Etherington commented that his experience has been that while positioning and lighting might be difficult, if a borescope is properly positioned one can get a close view of a 1/2-inch machine screw including surface scratches. Dr. Bush agreed and suggested that Mr. Kats was perhaps being overly conservative.

Mr. Kats commented that he also agreed if one knew before hand what one was looking for but if one is observing a rough spot, for example, adjacent to a weld deposit area as part of a scan of surface the situation would not be so clear.

Mr. MacMillan then stated that in his opinion the situation with respect to the Babcock and Wilcox designs was similar to that of the Westinghouse Corp. in terms of compliance with the criterion on accessibility for visual inspection. The capability exists for meeting the criterion although it would be time consuming in terms of removal of all vessel internals. There is ready

access to the vessel flange and seal area and B&W customers are encouraged to perform careful inspections of these and of the reactor vessel studs at each refueling. There is access to the inside of the vessel closure head when it is removed for refueling. The core support barrel and the upper core structure are readily accessible and the inside surface of the vessel is also accessible without removal of core internals through the check valves in the upper core barrel. The lower vessel head could be inspected through a vacant fuel element position with a device no more than 1/2 inch in diameter.

If a more extensive inspection than is possible with the above capability is thought desirable, the fuel assemblies and core internals could be removed. A water level would be necessary in the vessel to keep the radiation level down and inspections would be carried out through the water. At present there are plugs in the shield ring for access to the inlet and outlet nozzles and the core flooding nozzles which insert directly into the vessel in B&W designs.

There is access with some difficulty to the entire exterior surface by the removal of insulation. The biological shielding, which is removable in sections, would also have to be removed to allow access to the lower sections of the reactor vessel. High radiation levels would exist in this area, of the order of several R/hr, so that inspection of the entire exterior vessel surface would be difficult although possible.

Mr. MacMillan concluded that B&W had attempted to provide flexibility in accommodating inspection of both the inside and the outside surfaces of the reactor vessel if this is indicated.

Mr. Case asked about the time involved in performing such inspections. Mr. MacMillan replied that this had not been considered in detail although removal of the closure head, the fuel assemblies, the vessel internals and the reinstallation might take several months not including the inspection procedure itself. If this is considered in conjunction with a normal refueling operation, the increment of time over and above that for normal refueling would, of course, be somewhat less.

Mr. Palladino asked how difficult it would be to inspect the entire vessel outside surface. Mr. MacMillan replied that a three-foot annulus would be available after removal of the flange seal plate and shield plugs. This would also be a high radiation zone. He noted that B&W is now working on a program of inspection but details are not yet available. He pointed out, however, that access has been provided so that the exterior vessel surface would be inspectable if it became necessary. Dr. Bush asked if the nozzle transition welds were accessible and if more of the primary piping could be seen. Mr. MacMillan noted that some room has been left around the primary coolant pipe below the transition weld but again this is not an easily accessible area. It would not be necessary to chip concrete to view this section of the piping but otherwise it would represent a difficult job.

In answer to Mr. Case Mr. MacMillan commented that he could see no significant [illegible] possible for accessibility to the inner vessel surfaces.

Dr. Okrent asked if B&W designs also included a removable plug in the core support plate so that the bottom head of the reactor vessel would be viewable. Mr. MacMillan noted that the bottom head of the vessel could be approached [illegible] through the intervessel vent valves in the upper core barrel or through the [illegible] assembly location but that no removable plug in the core support [illegible] was included. If it became necessary to inspect the bottom head at each refueling some modification of the design would be required. Palladino asked whether presently available lighting was adequate or any development program on light sources was being undertaken. Mr. Hershey replied that lighting was, of course, the key to good visual inspection and that this might present difficulties if the bottom head of the vessel had to be inspected through a 1/2-inch hole. He noted that B&W at present has no development program on lighting sources. Mr. Kato answered that Westinghouse personnel have used five-watt sealed beam lamps which have worked quite successfully and in addition the borescopes contain their own light sources for local illumination. He suggested that lighting would not represent a major problem in terms of visual inspection.

Dr. Okrent asked if any undesirable features could be seen in performing such a removal of core internals as has been discussed and inspecting the vessel inner surfaces other than the cost in terms of time. Mr. Kato could not see any contra-indications although Mr. MacMillan suggested that in spite of the careful design of handling equipment some degree of risk exists whenever heavy equipment is [illegible] If any mishandling occurred, however, it would be in the nature of broken cables, etc., and would be readily detectable.

Mr. Etherington asked if there was any reluctance to pull the reactor vessel studs each year. Mr. MacMillan replied that all reactor vessel studs were removed at each refueling although it was not yet determined what percentage of these would be inspected each time.

Mr. Hubbard noted that in terms of visual inspections of General Electric reactor designs the vessel head and seal surfaces are readily accessible as is the upper area of the reactor vessel and some sections of the lower area. There are, however, some areas of the vessel internal surface, such as those sections which are located behind thermal sleeves in nozzles, which are not accessible.

Mr. Hubbard suggested representative sampling as an answer to continued in-service integrity assurance rather than 100% accessibility. He noted that he has also had considerable experience with the use of television and underwater photography in conjunction with voice recording of descriptions of the sections being viewed. These are later reproducible for an audience.

In terms of outside surface inspections this can be done in the area of nozzles and it is thought that the condition of the vessel can more readily be assessed from these areas than from a 100% inspection. Dr. Bush asked if the bottom head of the vessel could be viewed with TV cameras and a borescope. Mr. Hubbard replied that this was possible by looking at a small section at a time but that there would be some blind spots such as those noted above. The resolution is of course a function of the light available and the angle at which the light is directed onto the surface as well as how close one can effectively place one's eye to the surface and the speed of the traverse. Dr. Bush asked if the situation was at all different from that represented during the Quad Cities review in terms of removal of core internals. Mr. Hubbard replied that it was no different and that approximately six months would be necessary to remove core internals to perform a visual inspection of the vessel inner surface and replace the reactor core.

Mr. Palladino asked what could be viewed if this six-month period were available. Mr. Hubbard replied that approximately 80% of the vessel interior could be inspected and those sections of the core internals which would be left behind. Dr. Okrent asked if the time period had been on the same basis as those given previously, that is the increment added to normal refueling downtime not including the time necessary for inspection. Mr. Hubbard replied that without inspection time he would guess that it would take approximately one to three months in the special handling and removal of the remaining part of the fuel. Mr. Smith suggested that replacement of core internals with the same assurance of integrity as the original installation would require approximately four months since there is a very real problem with underwater reassembly even when components can be approached as closely as could be done by a diver. Without [illegible] the situation would be even worse. Mr. Hubbard noted that what was being suggested was really two conflicting requirements. Access means removability of core components but these must then be restored. GE has tried in its design to eliminate mechanical fasteners and use all welded construction to avoid the problems such fasteners can pose and to assure the necessary integrity. There seemed in Mr. Hubbard's view to be a conflict between inspectability, that is accessibility, requirements and necessary integrity assurance. Mr. Palladino asked if there were any plans for provision of additional accessibility or for re-examination of the whole question in GE design. Mr. Hubbard replied that to his knowledge there were no such plans.

Dr. Okrent asked with reference to the blind spots noted around thermal sleeves whether the two previous speakers could comment on this point. Mr. Kats replied that Westinghouse designs, with all of the internals removed, provide 100% access to the cladding surface and that no thermal sleeves are included in vessel nozzles. Mr. MacMillan replied that B&W designs include thermal sleeves within some nozzles and these would therefore not be inspectable from inside. There are, however, other ways to inspect these

nozzles. Dr. Okrent asked if Westinghouse and B&W felt the same reassembly assurance problems existed. Mr. Zatz replied that Westinghouse-designed reactors have no such bolting problems since core internals find their position by gravity and premachined slots and key ways. Mr. MacMillan replied that the situation with B&W designs was essentially the same and that no fasteners were used.

Mr. Case asked what GE's course would be if the AEC leans toward the requirement of elimination of blind spots in vessel inspection. Mr. Hubbard replied that he could not answer that question immediately, that the situation was being looked at but that more time would be necessary. Dr. Okrent asked if a plug in the core support plate would be feasible and would provide better visibility of the bottom head. Mr. Smith noted that this would not help visibility much because of the multiplicity of control rod guide tubes penetrating the bottom vessel head.

Mr. Case asked if he could sum up the GE position on the criterion for access for visual inspection as follows:

> In present GE designs access is possible to about 80% of the interior of the reactor pressure vessel. The time increment over and above normal refueling which would be necessary is approximately four months at a minimum.

Mr. Hubbard and Mr. Smith thought this was a fair statement. Mr. Hubbard added that in terms of resolution one would expect to see a crack approximately 1/32 of an inch wide, depending on the angle of the lighting. Sensitivity and resolving power on that order would be expected, however.

Mr. West then spoke for Combustion Engineering Co. The situation with regard to visual inspection of the vessel interior is similar to that for the Westinghouse and B&W designs. That is, the core barrel and reactor internals are removable with some difficulty so that the total vessel interior can be inspected. The bottom head is also visually inspectable with some difficulty as is the junction between the large nozzles and the vessel proper. Mr. West emphasized that the total inner surface of the reactor vessel including all nozzles, etc., would be inspectable. He expressed some reluctance to discuss the time required to prepare the vessel for such an inspection since he felt this to be properly the province of the utility operators. Dr. Okrent asked for some clarification of the term "with difficulty". Mr. West noted that very large sections, that is 12 feet in diameter by 30 feet long, would be involved and these are inserted with wedging to restrain them against vibration and only small clearances are therefore allowed. In addition, the work on these large sections would of necessity be done from a distance so that the initial installation would be a much simpler problem than removal and reinstallation subsequent to some period of reactor operation.

Dr. Okrent asked if the design might be changed if it were clear that internals would have to be removed some number of times greater than one throughout the reactor lifetime. Mr. West replied that off hand he doubted whether it would be prudent to loosen the clearances but the question would have to be reconsidered in detail in order to determine whether some modification was possible such that the design would still be adequate in terms of operation but would allow easier access.

Mr. West noted that CE designs include plugs in the core support structure the largest of which is several inches in diameter, with many others one to two inches in diameter. Probes could therefore be inserted and the bottom head inspected. The largest of the holes in the core support structure, app approximately six inches in diameter, has a bolted closure plug; bolts rather than welding being used to allow access. Mr. West noted that while it is rare to drop components in reactor vessels there may arise the need to remove small articles so that fairly easy access was thought to be necessary. Usually CE has no responsibility outside of the reactor vessel; the biological shielding design being the responsibility of the architect engineer with some CE advice. Thus far all CE reactors have allowed a few inches of clearance around the vessel so that a borescope could be inserted to view the external surface. Typically, insulation has not been included around the bottom head. From the nozzle area down to the core the vessel is insulated and this insulation is difficult to remove. In the region of the nozzles CE generally advises the architect engineer to provide access to the outside of the piping. Around the pressure vessel itself, however, such access would not be available.

Mr. West observed that he was inclined more toward the CE estimate of the time increment involved in readying a vessel for such a complete inspection, that is, two months at a minimum looks like an optimistic estimate. Dr. Beck asked how much of the inner surface of the vessel would be accessible without removal of the internals. Mr. West replied that the bottom head could be viewed through the grid plate but that the cylindrical portion of the vessel could not be inspected because of the core barrel. The main coolant nozzles could also be inspected. Mr. Case asked what the CE reaction would be to a requirement to inspect approximately 25% of the vessel's surface at each refueling. Mr. West noted that after the top and bottom head were inspected the next increment of surface would represent approximately a 100% exposure since the core barrel would have to be removed in any case.

Dr. Okrent asked if the two-month estimate was for the removal of fuel over and above that removed during a normal refueling, removal of the core barrel, replacement of the core barrel and additional fuel. Mr. West replied that that had been the basis of his estimate and stated that he thought this to be an optimistic guess for the incremental time addition and that the utilities should really be asked to comment on this point. Mr. Etherington asked whether any fasteners were used on the bolts holding down the core support structure access plate. Mr. West replied that both welds and crimped locking devices are used in various places within CE reactor vessels. In this application he suggested that a crimped locking device would be more satisfactory. Dr. Okrent

then asked how Westinghouse affected such closures. Mr. Kats replied that on the smaller plants the weight of the core structure itself is sufficient for holddown of such access plate. On the larger plants which have a higher pressure drop through the core and consequently greater lifting forces, crimped locking devices on holddown bolts are used. These locking devices are deformed by tanking, and can be lifted off by the tool used to remove them.

The discussion then turned to the second of the two criteria, that concerning accessibility for volumetric inspection of the vessel plate.

> "Practical means of access to the surface of the reactor pressure vessel should be provided so as to permit inspection of essentially 100% of the volume of pressure vessel material, either from the inside or outside of the vessel or a combination thereof. The purpose of this access is to permit thorough inspection of the vessel at appropriate intervals by visual means and ultrasonic or other suitable methods."

Dr. Bush listed the objectives of this criterion.

1. Detection of fatigue crack development in critical areas of the vessel such as at nozzle - shell intersections, bolting flange - shell and bolting flange - head junctions, closure studs, and flange areas surrounding the studs.

2. Detection of the growth of manufacturing flaws within the walls of vessel materials, which may have escaped detection during fabrication.

3. Examination of cladding material of the vessel for evidence of surface or sub-surface micro-fissuring and its progress into the vessel wall.

4. Examination of weld integrity, (including weld metal and weld-vessel material interface) of principal strength joints in the vessel proper, at nozzles and the control rod housings connection to the vessel head, and at transition sections between vessel nozzles and connected piping.

Mr. Davies of B&W led off. With respect to reactor vessel design he would see no difference between provisions for visual surface inspection and inspection of the material volume. He was also not aware of appropriate and significant changes in design which would allow easier access for such inspections. He thought that for the future ultrasonic inspection offered good possibilities for development but that its practicability in terms of in-service inspection had yet to be demonstrated. He did not care to predict the results of present developmental programs on infrared and acoustic emission techniques. Mr. Davies thought that essentially the same steps would be taken to ready a vessel for a volumetric inspection as for a visual surface inspection. The capability exists to inspect the same sections of the vessel in either way

without removal of internals and felt that the areas which could be so inspected represented the weak links in terms of the vessel integrity and should be those which were concentrated on most heavily.

In his opinion the need for a 100% volumetric inspection had not been demonstrated. To illustrate he suggested that if a reactor vessel were decontaminated after use and was to be certified for reuse in a second facility a complete volumetric inspection would not be performed. Instead a dye check for surface flaws would be performed as would an ultrasonic inspection of welds but the types of failures of concern, in Mr. Davies opinion, do no occur subsurface. Mr. Case asked why an ultrasonic test of the complete vessel would not be done in such a case. Mr. Davies thought that needless problems would be raised concerning the interpretation from the findings. If an initial ultrasonic inspection of the complete vessel had been performed as a reference datum it would be some help but it was not clear how much. He noted that the techniques, equipment and standards keep changing making an interpretation of subsequent inspections extremely difficult.

Mr. Davies suggested, and Dr. Bush agreed, that the most likely area in which a failure would be initiated by many orders of magnitude was the heat affected zone or weld in an area of high restraint. Therefore, if flaws can be eliminated by ultrasonic inspection of welds and heat affected zones, the probability of a failure initiated in the bulk metal is extremely low.

Dr. Okrent pointed out that there are sections of the vessel in which the existence of a crack might be of much higher concern than a similar crack in other areas. These sections might also be inspected even though probability of a failure initiated in such areas is low.

Mr. MacMillan noted as a plant designer the access for visual inspection in B&W plants is thought to be adequate for volumetric inspections as well. He also felt that it is not clear what technique would be appropriate so that the design requirements are not clear. B&W has been concerned only with providing sufficient access. Mr. MacMillan added that it was doubtful whether a 100% volumetric inspection was necessary or desirable from an economic stand standpoint.

Dr. Bush disagreed that only economics were involved. He suggested that there might be risks in a 100% inspection since inevitably the scanning rate would be increased with a concomitant decrease in sensitivity so that significant flaws could be missed. If only the critical 10% of a vessel were being inspected one would be more likely to scan slowly at higher sensitivity and less likely, therefore, to miss significant flaws. Mr. Greenberg agreed and suggested that while discontinuities in the base plate are tolerated the welds are generally defect free. An inspection which included the plate as well as welds and heat affected zones might tend to overlook flaws in the weld areas which would be detected if only those areas were being examined. Mr. Greenberg also pointed out that his inclination would be to inspect the critical areas two or even three times before inspecting the base plate.

There was also some discussion of the extreme difficulty experienced in getting reproducibility between ultrasonic inspections even when performed soon after one another and by the same operators using the same equipment.

Mr. Smith of GE then spoke concerning the programs now being carried out to improve the volumetric inspection techniques. He discussed programs now being carried out under the auspices of the PVRC and the Edison Electric Institute [illegible] aimed at the design and development of mechanized inspection techniques particularly in critical areas of pressure vessels. The programs will be aimed both at modification of existing techniques and the development of new techniques such as the use of installed transducers. Mr. Smith was of the opinion that a really satisfactory in-service inspection approach might be available within five years but noted that accessability to the critical areas would be necessary in order to utilize it and suggested that this was being provided in present GE designs. Access is available to the areas which are considered of most concern, mainly the nozzle areas and the flange - shell connection.

Mr. Case asked if an 80% access for visual inspection was equivalent to the capability of inspecting 80% of the vessel volume in GE designs. Mr. Smith replied that it was not. He noted that it was not clear that a volumetric inspection from the inside of the vessel would be adequate because of the high noise level resulting from the cladding. He suggested that an outside based inspection would be better. There will therefore be access to the outside surface of nozzles and the flange. Mr. Smith noted that in the material now in use for reactor pressure vessels the heat affected zones have the best impact properties of the vessel and the lowest transition temperature. A sizeable mechanized ultrasonic inspection device could probably be placed around all of the big nozzles, the vessel head, the vessel shell flange and the control rod drive connections. This would probably include about 10% of the total vessel material volume and approximately 25% of the total weld footage and heat affected zone volume.

Dr. Bush asked if it were possible to eliminate the noise resulting from the cladding surface roughness and if the internals could be removed how much of the inner surface would be accessible for volumetric inspection. Mr. Smith replied that in any case it would not be possible to get below the core support plate so that only 50% of the inner surface area would be accessible. There is some space between the shroud and vessel wall so that with appropriate fixtures about 2/3 of the vessel barrel section and about 1/2 the core region could be inspected. [illegible] all about 70 - 80% of the vessel material volume would be inspectable [illegible] if core internals were removed. Not much in addition to this could be inspected by approaching the vessel from the outside since the surface will be insulated and there will not be sufficient space to remove the insulation.

In response to a question by Dr. Okrent the CE representatives pointed out that the vessel in the vertical area is insulated on CE designs but that the insulation is affixed to the shield rather than the vessel at the bottom head.

B&W representatives noted that insulation is included on the vessel vertical sections but is independently supported on the upper head. However, they noted also the insulation will be radioactive and must, therefore, be stored. Mr. MacMillan concluded that for B&W designs access to the vessel material volume from the outside verges on being marginal.

Mr. Katz and Mr. Lorentz agreed that in terms of the noise level resulting from cladding surface roughness problems associated with ultrasonic inspection from within the vessel were not insuperable. A defect approximately 10% of the wall thickness could be readily found. Mr. Lorentz added that with materials such as are presently in use these are the defects which are of interest.

Mr. Katz of Westinghouse commented that with respect to a volumetric inspection he agreed with Mr. Smith that it might take as long as five years to develop an adequate technique. It is now necessary to decide what should be provided so that the techniques not presently available could be utilized in future. He added that in his opinion ultrasonic inspection would provide the basis for these yet to be developed methods. Westinghouse has, therefore, tried to allow accessibility for in-service ultrasonic inspection. In addition, Westinghouse is now investigating with the vessel manufacturers the performance of ultrasonic inspections of completed vessels to provide a reference base for future tests. Such a base is necessary in order to detect any changes which may occur. Westinghouse agrees with the other spokesmen so far, however, that the tests should properly be of selected areas rather than 100% of the vessel volume. Plans include the incorporation of the PVRC Subcommittee/Into results future Westinghouse designs.

Mr. Etherington asked if the reference maps being made would be of 100% of the vessel volume. Mr. Katz replied that this had not yet been decided, nor had the response to any unexpected indications resulting from this reference mapping. He noted that at the time of this overall inspection the vessel will already have met all code requirements and this last test will not be a code required test. Any indications would certainly be recorded but repairs might not be effected.

There followed some discussion of the need for performance of reference-base tests in a manner similar to future tests to be made. Some of the vendor representatives present felt that in order to be meaningful future tests and reference-based tests must be performed in the same manner with the same orientation and equipment and if possible by the same technicians. Even in such an extreme case the utility and reproducibility of the tests might be doubtful.

Mr. Givons of Combustion Engineering noted that many of the points which he had to make had already been made but that he intended to repeat them. A 100% volumetric inspection is not now feasible for CE designs. He felt that selected areas only should be examined. Ultrasonic inspection has not yet been demonstrated as an effective in-service test on an irradiated vessel but

that he personally was looking to the PVRC program to develop this capability. Access from the interior of the vessel is now considered adequate for large defects and ultrasonic inspection should be confined to a search for such significant defects only and the technique should not be pressed to the limit of its capability. To get an effective ultrasonic inspection, competent and qualified personnel are absolutely necessary. A baseline inspection using the same techniques and equipment as are to be used in the in-service inspections must be performed. Mr. Givons reiterated that in his opinion the baseline and in-service tests must be really identical. Dr. Okrent asked why this was necessary if only gross defects were being sought. Mr. Givons replied that changing even minor conditions of the test might produce spurious signals and would make the detection of changes very difficult. Mr. Givons concluded that the definition of the magnitude, frequency and location of defects to be considered unacceptable was necessary as was a correlation of defect growth with service conditions including radiation. He noted that the PVRC program was again being looked to to provide these.

Prior to the luncheon break, Dr. Okrent posed the following questions:

1. What are the relative merits of periodic hydrotesting at some pressure above design pressure and

2. How does this compare with periodic careful inspection?

Following lunch the meeting reconvened. Mr. Smith opened the discussion; he felt that hydrostatic testing and periodic inspection could not substitute for one another. He cited as an example the failure of a large vessel on its fourth hydrostatic test. This vessel had incorporated in it a large flaw and had been pressurized at about 100° below its transition temperature. Mr. Smith also cited a recent international meeting at which this question was discussed. The conclusion of those present was that repeated overpressure testing is not indicated with the materials presently available. Mr. Smith agreed in answer to a question by Mr. Etherington that there would be a distinction between a test at twice design pressure and one at 10% above design pressure. The test at twice design pressure would produce significant strain in many areas of the vessel and indications are that at approximately 1% strain strain aging of the material now being used for reactor pressure vessels becomes a significant factor. The 110% design pressure test would strain only small areas by comparison and would do relatively little damage. The conclusions of the international conference cited above actually centered on not exceeding 110 - 120% of design pressure.

Mr. Beckjord commented that Westinghouse would also answer that hydrostatic testing and volumetric inspection cannot substitute for one another.

Mr. Lorentz noted that his personal experience with hydrostatic testing is that not all defects present are discovered.

Dr. Okrent pointed out that since the vendors as a group are proposing only partial ultrasonic inspection one could also conclude that the nondestructive test procedure will also not reveal every flaw. Mr. Lorentz and Mr. Greenberg, however, noted there is some experience which indicates that hydrostatic testing can in fact damage vessels and leave them in a less desirable condition.

Mr. Davies commented for Babcock and Wilcox. The initial hydrostatic test does more good than harm because it reduces the subsequent strain range within which the vessel operates; that it high stress areas will yield during the test and redistribute their stresses. Subsequent hydrostatic tests, however, are considered to be good only as leak tests.

Dr. Bush thought it was worth noting, without personal comment, that at the IAEA meeting held in the Fall of 1966 the opinion of the group concerned with this question was that repetitive hydrostatic testing was a desirable procedure. This position was strongly supported by the German and Swedish delegations to the meeting so that the overall situation is apparently not one of complete agreement among the experts.

Following this the vendors met in private with the representatives of the regulatory group.

C. BABCOCK AND WILCOX CORP.

Dr. Mann asked what the reaction of the B&W representatives would be to the promulgation of criteria of the sort discussed in Mr. Price's letter.

Mr. MacMillan replied that he had already stated B&W's position during the opening session. The accessability of the interior of the reactor vessel is not a problem but would represent a matter of time and inconvenience. He noted that the accessibility now being considered would require the vessel to be flooded and if dry access was desired some design modification would be necessary. He could, however, see no advantage to dry access at this time.

On volumetric inspection he did not understand what techniques were being anticipated and noted that B&W had tried to retain flexibility by providing access, although difficult and only marginally practical. He also repeated that in his opinion a 100% volumetric inspection was not needful and that critical areas of the vessel should be concentrated on. Dr. Mann asked what his opinion was concerning preoperational mapping by nondestructive test methods. Mr. MacMillan replied that he thought it had been well learned that one must inspect in the same way with the same equipment and under the same conditions as would be done subsequently in order to get reproducible results. This was true even though sizeable cracks were being sought.

Mr. Palladino asked what normal practice was on non-nuclear vessels. Mr. Davies replied that procedures on steam drums vary that the surface is generally inspected in a somewhat cursory manner and then the areas of attachment of penetrations, etc., are closely inspected. This represents in some way a combination of both the critical area and general inspection.

Mr. Case pointed out that one should not necessarily equate accessibility for a 100% volumetric inspection with inspection of 100% of the material volume each time.

Mr. Mangelsdorf asked what method of inspection has been found to be most effective. Mr. Davies replied that in his opinion visual inspection and surface inspection by magnafluxing were most effective. He added that the criterion concerning accessibility was not of concern but the question of concern would be how much inspection and how often.

D. COMBUSTION ENGINEERING

Dr. Mann asked what CE's position would be with respect to promulgation of criteria such as were proposed in Mr. Price's letter. Mr. West replied that it is now feasible to visually inspect and ultrasonically test CE vessels. The internals are completely removable. As to the advisability of such inspections he thought them unnecessary and expensive. It was not clear to him what the utility of a visual inspection would be except to discover unanticipated events such as loose components within the vessel. In view of the large amount of money involved in performing such a test, should ultrasonic inspection be considered necessary, he suggested a heavily supported/to provide a nondestructive test which would be meaningful.

Mr. Etherington asked if CE would take the same view of hydrostatic testing on conventional Section I vessels as they had taken on nuclear vessels. That is, that a hydrostatic test above design pressure is not necessary. Mr. Lorentz replied that it is now a code requirement to perform a hydrostatic test periodically and that these are done but are considered leak tests only. Mr. Palladino asked for some clarification of Mr. West's statement that inspections are not necessary. Mr. West replied that of course this depends on the price tag. Inspection of nozzle areas would be acceptable as would a borescoping of the bottom of the reactor vessel. However, removal of the core barrel represents a step function in the price tag and therefore is considered unnecessary. Mr. Palladino pointed out that the excellent history of operation of pressure vessels has generally been considered to be associated with the widespread use of visual inspection. Mr. Lorentz replied that conversely when a failure has occurred it is almost always due to something gross and is preceded by warnings of one kind or another.

Dr. Mann noted that the point at issue now was the reaction of CE to the criteria for accessibility. Mr. West replied that CE's reaction would not be adverse since their vessels are accessible as a matter of simple prudence.

E. WESTINGHOUSE ELECTRIC CORP.

Mr. Case asked what Westinghouse's position would be on criteria such as were described in Mr. Price's letter. Mr. Beckjord replied that he felt that Westinghouse was already complying with the criteria and had done so starting with the San Onofre and Connecticut/ plants. There have also been plans in effect beginning with the Rochester and Indian Point 2 plants to provide a reference base ultrasonic test of approximately 70% of the vessel volume although a 100% inspection would be feasible. Mr. Beckjord also noted that a hydrostatic test was not considered equivalent to nondestructive test methods. Mr. Beckjord added that while Westinghouse intended to carry through its plans on volumetric inspection details will have to follow the development work now going on on ultrasonic test methods. No schedule is yet available for periodic retesting in Westinghouse plants although he believed that such a program would be effected.

Dr. Okrent asked if the two-week time increment suggested for the performance of such an in-service inspection of the vessel surface was really considered a realistic estimate. Mr. Katz replied that it was based on the removal of the lower core support structure several times at the San Onofre plant. The difficulty of fit at the radial support member was not found to be a problem. He suggested that the estimates made by the other vendors present at the meeting might have been based on the lack of experience or earlier adverse experience. He did not feel that the Westinghouse estimate would be changed by radiation since fuel handling type equipment had been used. Mr. Katz repeated that the two-week figure cited was above and beyond the time required for normal refueling operations and did not include the time required for the inspection itself.

F. GENERAL ELECTRIC CORP.

Mr. Case asked what GE's position was concerning criteria of the type suggested in Mr. Price's letter. Dr. Greager replied that it was now felt necessary to know more about the specific nondestructive test methods posed before these could be used as bases for criteria. Dr. Mann pointed out that what was now being discussed was the criterion for accessibility itself. Dr. Greager noted that it was difficult to determine what access provisions to allow if it was not clear what would be necessary. He repeated that it was first necessary to develop techniques.

Mr. Case thought that a distinction had been made by the Regulatory Staff which separated the development of the techniques from making space available so that the techniques could be used when they had been developed.

Dr. Okrent noted that it was still not clear to him what the practicality was of the access to the outside of the vessel which had been discussed. Mr. Hubbard replied that there is easy access to the major nozzle areas and that the question arose in connection with access to the barrel areas. Feasibility

at this location would be associated with moving the shield wall back and it was not now clear how far back the shield wall would have to be moved. GE's position in general is that there now exists an adequate test program for the present generation of reactor vessel without modification.

There was a great deal of discussion concerning the possibility of various modifications which would allow an increase in the annular space between the biological shield and the reactor vessel insulation. The Westinghouse personnel repeated the difficulty of providing such an increase without at the same time increasing the total containment volume, etc. Mr. Palladino noted that it is presently anticipated that the vessels now under construction would last 40 years. If access is provided any techniques developed would be useable. Dr. Greager replied that in his opinion GE was now providing the access necessary to perform inspection as required to assure the vessels would perform as designed. Any addition in accessibility and testing are apparently based on the assumption that if these are not provided one is taking the risk of a catastrophic event. Dr. Greager felt it more likely that 15 years of development effort would indicate that the vessels as they are presently being fabricated with the techniques available would fail, if at all, through slow leaks and without risk to the public health and safety. Mr. Palladino agreed that the underlying premise was indeed that if such inspections are not performed a significant risk of catastrophic failure exists. He noted also that the reason most offered for the high degree of success of pressure vessels in non-nuclear service is periodic inspections. The tendency, however, has been to bury reactor vessels after construction.

There was additional discussion of the problems associated with providing an increase in the space available around the outside of GE reactor vessels. Dr. Greager pointed out that any approach to increased accessibility calls for some penalties and felt that a more substantial reason should be available than the supposition that there will be a meaningful inspection technique available in the future. Mr. Case

Mr. Case asked how long it would take to perform the necessary design changes if the Commission decided to promulgate criteria calling for increased accessibility. Dr. Greager did not feel that he could answer that question. Mr. Smith asked again why it was considered unnecessary to inspect more than just the so called critical areas of the vessels. Mr. Case replied that accessibility was necessary to allow one to accommodate a new definition of critical areas should one arise.

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August 12, 1968

SECRETARIAT

AEC 943/45

APPARENT DEFICIENCIES IN ASME BOILER AND PRESSURE VESSEL CODE, SECTION III "NUCLEAR VESSELS"

Note by the Secretary

The General Manager has requested that the attached memorandum of August 6, 1968 from the Director of Reactor Development and Technology be circulated for the information of the Commission.

F. T. Hobbs

Acting Secretary

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