Jim McKnight
05F22

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

March 10, 1995

NRC INFORMATION NOTICE 95-17: REACTOR VESSEL TOP GUIDE AND CORE PLATE CRACKING

Addressees

All holders of operating licenses or construction permits for boiling water reactors (BWRs).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees that significant cracking has been observed in the weld regions of the reactor vessel top guide and core plate in an overseas BWR. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

During the 1994 inservice inspection of the Wuergassen BWR in Germany, significant cracking was visually observed in the reactor vessel top guide and core plate. The cracks were circumferentially oriented along the weld regions and were located in the rim areas of the top guide and the core plate (see figure in Attachment 1). The top guide and the core plate were made of niobium stabilized austenitic stainless steel (SS) (equivalent to American Iron and Steel Institute Type 347 SS) and were post-weld heat treated during fabrication. The Type 347 SS material had a relatively high carbon content and a minimum niobium-to-carbon ratio. Samples of this material had passed a standard sensitization test. Significant cracking was also found in the core shroud, which was made of the same material. The root cause of the observed cracking is still under evaluation.

Discussion

Early in 1991, minor cracking not associated with a weld was observed in a cross beam of the top guide in a domestic BWR (Oyster Creek). Subsequent monitoring and assessment of the cracking showed that the structural integrity of the top guide was maintained. The cracking observed in the overseas BWR is considered significant because it was the first time cracking was found in the ring weld regions of the reactor vessel top guide and core plate.

On November 22, 1994, General Electric (GE) issued Rapid Information Communication Services Information Letter No. 071, "Top Guide and Core Plate Cracking," which discussed the cracking event reported in the overseas BWR. The overseas BWR had accumulated approximately 13 years of hot operating time and the average conductivity of the reactor water during the worst five fuel cycles had been 0.22 microsiemens per centimeter [0.56 micromho per inch]. Although the overseas BWR was not a GE BWR and the GE-design BWRs have several different configurations of the top guide and core plate assemblies, there are similarities in the designs. For example, GE noted that welds existed in GE BWRs (domestic BWRs) in areas that were cracked in the overseas BWR. In the overseas non-GE BWR, Type 347 austenitic SS was used for fabricating the top guide and the core plate, instead of Type 304 austenitic SS, which was used in domestic BWRs. GE has tested Type 347 SS for its resistance to intergranular stress corrosion cracking (IGSCC). On the basis of tests, GE has concluded that sensitized Type 347 SS has a susceptibility to IGSCC equivalent to that of sensitized high carbon Type 304. When Type 347 SS is not sensitized, it has a susceptibility to IGSCC equivalent to that of Type 304L SS that is not sensitized. GE concludes that domestic BWRs with a similar amount of hot operating time may expect cracking to occur in the top guide and the core plate.

The BWR Vessel and Internals Project (BWRVIP), by letter of January 3, 1995, reported the GE evaluation of the safety significance of this cracking event as it pertains to domestic BWRs. The nonproprietary portion of the BWRVIP letter is given in Attachment 2. A BWRVIP report for all internals, discussing IGSCC susceptibility ranking, safety consequences, inspection scopes and methodologies, flaw evaluation, repair strategies and mitigation of degradation is expected in the latter half of 1995.

The NRC staff will monitor the inspections of top guides and core plates in the industry. The staff is evaluating the safety implications of cracking in these areas to determine whether additional generic communication is needed.

<u>Related Generic Communications</u>

On September 30, 1993, the NRC issued Information Notice (IN) 93-79, "Core Shroud Cracking at Beltline Region Welds in Boiling-Water Reactors," in response to the discovery of cracking of the core shroud welds at Brunswick Unit 1 plant. Following the additional discovery of core shroud cracks at Dresden Unit 3 and Quad Cities Unit 1 in 1994, the following additional generic communications were issued: 1) IN 94-42, "Cracking in the Lower Region of the Core Shroud in Boiling-Water Reactors," on June 7, 1994; 2) Supplement 1 to IN 94-42 on July 19, 1994; and 3) Generic Letter 94-03, "Intergranular Stress Corrosion Cracking of Core Shroud in Boiling Water Reactors," on July 25, 1994.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Brian Grimes

Brian K. Grimes, Director
Division of Project Support
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Technical contacts: W. H. Koo, NRR
(301) 415-2706

E. M. Hackett, NRR
(301) 415-2751

T. A. Greene, NRR
(301) 415-1175

Attachments:
1. Figure, "Location of Cracking in Top Guide and Core Plate"
2. Letter from BWR Vessel and Internals Project to U.S. Nuclear Regulatory Commission, "Request for Information Regarding the Impact of BWR Core Plate and Top Guide Ring Cracking," January 3, 1995
3. List of Recently Issued NRC Information Notices

Attachments filed in Jacket

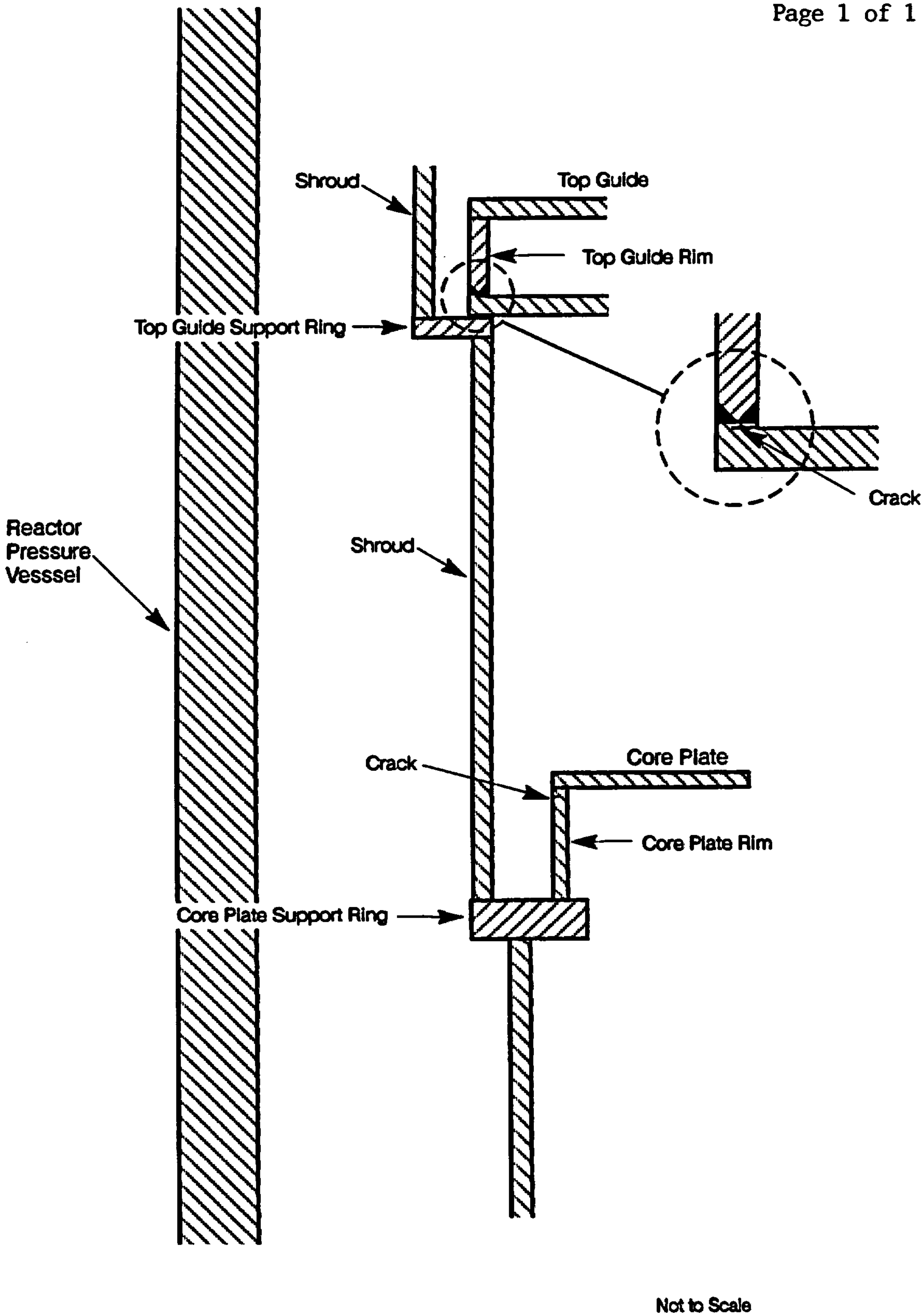

Figure 1. Location of Cracking in Top Guide and Core Plate

BWRVIP

BWR Vessel &
Internals Project

Issue Management and Resolution

January 3, 1995

U.S. Nuclear Regulatory Commission
Washington, D.C., 20555
Attention: Document Control Branch

SUBJECT: **Request for Information Regarding the Impact of BWR Core Plate and Top Guide Ring Cracking**

In response to a request for information on the subject, the BWRVIP is providing the information in this letter on relevant design aspects of BWR core plates and top guides and the impact that recently discovered outer ring cracking could have on the safety performance of these components.

In order to provide this response on an expedited basis, the information below has not been reviewed by all BWRVIP utility members. GE has based the information presented here on top level drawings, such as reactor assembly drawings, in most cases. There may be cases where field modifications occurred during fabrication which are not shown on the reactor assembly drawings. Any such modifications would improve the component condition relative to that reported here, so the information here is expected to be conservative. However, individual utility reviews of plant-specific configurations may reveal some minor differences from the information presented here.

CORE SUPPORT PLATE

The safety function of the core support plate is to provide lateral support and positioning for the control rod guide tubes, which in turn support all but the peripheral fuel assemblies, such that control rods can be inserted and the core can be cooled following an accident. While there may be minor differences in core plate designs from plant type to plant type and plant to plant, the design characteristics of importance relative to the ring weld cracking issue are essentially the same for all plants. A description of a typical core plate follows. The core plate consists of a 2 inch thick circular plate with CRD guide tube holes about 11 inches in diameter. A cylindrical rim is welded under the plate (full penetration), and the rim-plate structure is reinforced underneath with a gridwork of beams and bars. The core plate is secured to the core plate flange of the shroud by multiple (from 36 to over 70, depending on the plant) preloaded stainless steel studs (see example in Figure 1). There is aligner pin hardware, which provides some lateral restraint between the

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Reply To: J. T. Beckham, Jr., BWRVIP Chairman, Southern Nuclear Operating Co., 42 Inverness Center Parkway, Birmingham, AL 35242 • (205) 877-7279 • Fax: (205) 802-0393

core plate and shroud, but the discussion here is focused on the presence of the preloaded studs.

The preloaded studs provide a large compressive load holding the core plate in place relative to the shroud. Friction between the core plate ring and shroud flange is sufficient to prevent lateral motion of the machined surfaces during a seismic event. The friction factor of a stress corrosion crack in the ring weld would be significantly higher, so even assuming through-wall cracking of the ring weld, the core plate would maintain its full design capability to resist displacements due to vertical delta-P and seismic loads and due to lateral seismic loads.

TOP GUIDE

Review of GE documents indicates that there are five basic top guide configurations. Table 1 lists the US BWRs under each configuration. The configurations are described in terms of their lateral support capability, which is the key issue for top guides. Sketches and descriptions of each configuration are provided in attachments, as follows:

Attachment 1: BWR/2
Attachment 2: Aligner Pin Assemblies Only (BWR/3,4)
Attachment 3: Aligner Pin Assemblies Plus Reinforcement Blocks (BWR/3,4)
Attachment 4: Aligner Pin Assemblies Plus Wedges (BWR/4,5)
Attachment 5: BWR/6

Potential for Vertical Displacement

In considering a seismic event, vertical seismic plus operating delta-P loading would not overcome the weight of the top guide. Based on recent TRACG analyses for a loss of coolant accident (LOCA) event, LOCA delta-P loads would not overcome the top guide weight. While time has not permitted a rigorous analysis of combined seismic plus LOCA vertical loads for all plants, it is expected that such a combination will not overcome the top guide weight. For example, recent TRACG results for a BWR/4 show a LOCA delta-P of about 1 psi. This represents an upward load of about 25% of the top guide beam weight. Therefore, a vertical seismic acceleration of about 0.75g would be required to overcome the top guide weight. For plants with hold-down bolts, there would be even more margin against top guide vertical displacement.

The discussion above applies to an intact, as-designed top guide. If complete ring weld cracking were assumed, the top guide assembly would still react to vertical loads as a single, effectively intact component, because there are about 200 welded pins connecting the top plate to the bottom plate through the beam connections.

Therefore, the ring weld cracking raises no new concerns relative to vertical top guide displacement.

Potential for Lateral Displacement

The top guide provides lateral support for the fuel during a seismic event, transferring the load from the fuel to the shroud. The means by which the lateral load is transferred to the shroud depends on the plant's top guide configuration, described in the Attachments. Likewise, the impact of ring weld cracking depends somewhat on the top guide configuration. Each configuration is addressed below.

BWR/2 Plants (Attachment 1)

The BWR/2 top guides are supported laterally by four vertical aligner pin assemblies plus eight lateral support brackets. The brackets are welded to the shroud and are sized to be within 1/16 inch of the top guide ring. Ring weld cracking does not degrade the capability of this combination of lateral supports.

The lateral support brackets are welded to the shroud with intermittent fillet welds; the associated creviced geometry could be SCC susceptible. However, there are no applied loads during operation, and the fillet weld residual stresses are considerably less severe than the residual stresses associated with weld geometries like the ring weld. It is extremely unlikely that enough of the redundant lateral support components would be sufficiently cracked to allow top guide displacement during a seismic event.

BWR/6 Plants and BWR/4,5 Plants with Wedges (Attachments 4 and 5)

The BWR/6 equivalent of the top guide, commonly called the grid, is quite different in design. The grid is integral with the upper shroud (comparable to the portion above H3). The grid/upper shroud assembly is bolted to the lower shroud with about 80 preloaded studs. The mechanical joint transfers the fuel seismic load from the grid into the shroud. There is no grid weld comparable to the ring weld in the top guides. Thus, the subject cracking is not an issue for BWR/6.

For some BWR/4s and all BWR/5s, lateral support wedge assemblies were added between the top guide and shroud to increase the seismic structural margin of the top guide. These wedges, numbering between 24 and 32 around the top guide perimeter, provide mechanical lateral restraint to supplement that of the aligner pin assemblies. Ring weld cracking does not degrade the capability of this combination of lateral supports.

The mating piece of the wedge assembly attached to the shroud is fillet welded, so there is some limited potential for SCC. However, it is extremely unlikely that enough of the redundant lateral support components would be sufficiently cracked to allow top guide displacement during a seismic event.

BWR/3 Plants and Remaining BWR/4 Plants (Attachments 2 and 3)

The BWR/3 plants and those BWR/4s not addressed above were designed such that the aligner pin hardware reacts the lateral seismic loads. Reinforcing blocks added in some plants increase the seismic loading capacity of the aligner hardware, but that arrangement still relies on the structural integrity of the aligner hardware welded to the shroud.

For these plants, ring weld cracking has a small, acceptable impact on the top guide margin preventing lateral displacement. The evaluation below discusses the impact of ring weld cracking, and then proceeds through several levels of hypothetical component degradation and system responses to show that even for extremely unlikely worst case scenarios safe shutdown would be achieved.

If the weld in the top guide ring were cracked:
The top guide beams attach to the outer ring assembly by pins in the top and bottom plates, which are connected by the ring containing the suspect weld. The load from fuel movement during a seismic event is transferred to the beams, then to the top and bottom plate via the pin connections. If the ring weld were completely cracked, the full load would have to be transferred through the pin connections to the bottom plate, then to the aligner pin hardware and finally to the shroud (in the case where there are no supplemental restraints like wedges). The load path from the fuel to the shroud bypasses the outer ring, if it were fully cracked, as long as the pins to the bottom plate remain intact. There are typically around 100 pins connecting the redundant beam structure to the bottom plate, so it is expected that, while some pins might shear, loads would redistribute and the overall structure would stay intact. Therefore, cracking in the ring would have an acceptably small impact on the top guide's ability to transfer the seismic load to the shroud.

Alignment pin hardware integrity:
The cracking of the ring weld indicates, as expected, that the environment in the top guide region is aggressive. It is possible that the aligner pin hardware could experience SCC. However, the likelihood of SCC being extensive enough that seismic loads could cause top guide lateral motion is quite low, for several reasons:

1. The aligner pin hardware is welded to the top guide and shroud with fillet welds or partial penetration groove welds. While some aligner brackets have crevices, most aligner pin hardware have welds all around, precluding crevice SCC. The amount of connecting weld is typically sufficient so that the pin is the highest stressed part of the alignment hardware during a seismic event. Thus, some SCC

could be tolerated before the connecting welds would have the highest stresses, and even more SCC could be tolerated before the welds would separate by shear.

2. The aligner hardware is redundant; there are four aligner pins in the top guide. For any given direction of seismic acceleration, three or four aligners would carry some of the top guide load. Thus, there would have to be significant degradation in most or all of the aligner hardware sets to allow top guide movement.

3. For plants with vertical aligner pins, the arrangement of the aligner pin hardware is such that for any direction of seismic acceleration, one or two sets of alignment pin hardware would be partially or fully blocking top guide movement, even if cracking had occurred. The top guide bottom plate and some beams would have to deform around the alignment pin hardware during the seismic event, which would limit displacements.

4. For plants with horizontal aligner pins, the hardware is attached by *uncreviced* fillet weld arrangements. Fillet welds generally develop smaller shrinkage residual stresses than partial or full penetration welds like the ring weld and shroud welds. Thus, the likelihood of SCC at these connecting welds is lower than for the ring weld. A VT inspection of the alignment pin hardware at Brunswick 1 was conducted when the shroud cracking was discovered (H3 was extensively cracked) and no cracks were observed at the bracket fillet welds.

5. For plants with reinforcing blocks, the blocks are attached to the top guide, providing additional bracing on either side of the shroud bracket which engages the aligner pin. If the aligner pin hardware attached to the top guide were to fail, the reinforcing blocks and intact shroud bracket would prevent top guide motion. However, if the shroud bracket welds failed, the top guide could move to the extent described in (3) above.

If the aligner pin hardware were cracked:
If several sets of aligner pin hardware were significantly cracked (quite unlikely) and a design basis seismic event occurred (very unlikely), the remaining alignment pin hardware fillet weld ligaments might separate by shear. For those plants with hold down bolts, the bolts would have to fail before the top guide could move laterally a significant amount. In some plants, the core spray sparger brackets welded to the shroud would contact the top guide after limited displacement. In the extreme case, the top guide could move 4 to 5 inches before contacting the shroud.

Control rod insertion has been tested successfully for fuel channel static displacements of up to 1.2 inches at the center of the channel length. This condition has conservatively been extrapolated to a top guide displacement of 2.4 inches for shroud repair discussions. Considering that the top guide displacement and control rod insertion would be occurring during a dynamic seismic event, it is reasonable to expect that fuel motion would allow insertion more readily than would a static situation. Dynamic tests of rod insertion with fuel motion have shown that comparable insertion results could be achieved with dynamic fuel displacement about 2.5 times the static displacement. This information supports engineering judgment that control rods would insert with a top guide lateral displacement of six inches, which is greater than the displacement of the top guide contacting the shroud.

If the top guide displacement occurred and control rods did not insert:
While the cumulative likelihood of the combination of events which must occur to reach this condition is extremely unlikely, the outcome is still safe shutdown. If control rods did not insert, standby liquid control would still be available. Failure of control rods to insert is covered in plant Emergency Operating Procedures, and operators are trained to respond to such scenarios. There is no scenario, including any involving loose parts, where failure of top guide hardware, top guide displacement or failed control rod insertion would disable the standby liquid control system.

CONCLUSIONS

All 36 operating US BWRs have core plates with hold-down bolts. Core plate ring weld cracking has an insignificant impact on core plate displacements under delta-P and seismic loading.

The top and bottom plates of top guides are connected in a redundant way so that ring weld cracking has an insignificant impact on the top guide response to vertical loads, whether or not hold-down bolts are present.

Twenty BWRs have lateral support configurations where ring weld cracking has an insignificant impact on top guide lateral load capability.

Sixteen BWRs have top guides where lateral loads are reacted by alignment pin hardware. For these, ring weld cracking can have a small, but acceptable, impact on top guide lateral load capability.

A number of additional hypothetical top guide component failures and associated system responses are evaluated, with the conclusion in all cases being that safe shutdown would be achievable.

The BWRVIP is using this information to incorporate appropriate core plate and top guide inspection and, if needed, evaluation/repair guidelines into the overall vessel and internals program, and will update the NRC on continuing development and implementation of this program.

If you have any questions, please contact Vaughn Wagoner, Technical Chairman of the BWRVIP Assessment Subcommittee, at (919) 546-7959.

Sincerely,

VWagoner for

Carl Terry, Executive Chairman
BWRVIP Assessment Subcommittee

c: D.S. Brinkman, NRC Senior Project Manager
J. T. Beckham, Jr., BWRVIP Chairman
S. LaBruna, BWRVIP Vice Chairman
R.A. Pinelli, BWROG Chairman
K.P. Donovan, BWROG Vice Chairman
BWRVIP Assessment Subcommittee Members

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
95-16	Vibration Caused by Increased Recirclation Flow in a Boiling Water Reactor	03/09/95	All holders of OLs or CPs for boiling water reactors.
95-15	Inadequate Logic Testing of Safety-Related Circuits	03/07/95	All holders of OLs or CPs for nuclear power reactors.
95-14	Susceptibility of Containment Sump Recirculation Gate Valves to Pressure Locking	02/28/95	All holders of OLs or CPs for nuclear power reactors.
95-13	Potential for Data Collection Equipment to Affect Protection System Performance	02/24/95	All holders of OLs or CPs for nuclear power reactors.
95-12	Potentially Nonconforming Fasteners Supplied by A&G Engineering II, Inc.	02/21/95	All holders of OLs or CPs for nuclear power reactors.
95-11	Failure of Condensate Piping Because of Erosion/Corrosion at a Flow-Straightening Device	02/24/95	All holders of OLs or CPs for nuclear power reactors.
95-10 Supp. 1	Potential for Loss of Automatic Engineered Safety Features Actuation	02/10/95	All holders of OLs or CPs for nuclear power reactors.
95-10	Potential for Loss of Automatic Engineered Safety Features Actuation	02/03/95	All holders of OLs or CPs for nuclear power reactors.
95-09	Use of Inappropriate Guidelines and Criteria for Nuclear Piping and Pipe Support Evaluation and Design	01/31/95	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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/s/'d by BKGrimes

Brian K. Grimes, Director
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2. Letter from BWR Vessel and Internals Project to U.S. Nuclear Regulatory Commission, "Request for Information Regarding the Impact of BWR Core Plate and Top Guide Ring Cracking," January 3, 1995
3. List of Recently Issued NRC Information Notices

DOCUMENT NAME: 95-17.IN

* See previous concurrences

OFC	*EMCB:DE	*EMCB:DE	*C/EMCB:DE	*PUB:ADM
NAME	WHKoo:wk:adl	RAHermann	JRStrosnider	Tech ED
DATE	01/09/95	01/09/95	01/09/95	01/18/95

OFC	*OECB:DOPS	*C/OECB:DOPS	*OECB:DOPS	*C/OECB:DOPS
NAME	TGreene	RDennig	RKiessel	AChaffee
DATE	01/26/95	01/26/95	02/21/95	02/27/95

OFC	D/DOPS
NAME	BGrimes
DATE	03/ 6 /95

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* See previous concurrences DOCUMENT NAME: S:\DOPS SEC\TOPGUIDE.INF

OFC	*EMCB:DE	*EMCB:DE	*C/EMCB:DE	*PUB:ADM
NAME	WHKoo:wk:adl	RAHermann	JRStrosnider	Tech ED
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2/3/95
H. Faulkner, IP has reviewed and has no objection to naming plant

DOCUMENT NAME: G:\TAG\TOPGUIDE.INF

* See previous concurrences

OFC	*EMCB:DE	*EMCB:DE	*C/EMCB:DE	*PUB:ADM
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DATE	01/09/95	01/09/95	01/09/95	1/18/95

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[OFFICIAL RECORD COPY] DOCUMENT NAME: G:\TAG\TOPGUIDE.INF cycles was 0.22 $\mu S/cm$. GE indicated that the subject overseas BWR is not a GE BWR, but the designs of the top guide and core plate are similar. GE also noted that similar welds existed in GE BWRs (domestic BWRs). In domestic BWRs Type 304 austenitic stainless steel (SS) was used for fabricating the top guide and the core plate, instead of Type 347 austenitic stainless steel which was used in the overseas non-GE BWR. GE has tested Type 347 SS for its resistance to intergranular stress corrosion cracking (IGSCC). Based on the tests, GE considers that Type 347 stainless steel has a susceptibility to IGSCC equivalent to that of Type 304L stainless steel when not sensitized, and is equivalent to high carbon Type 304 stainless steel when sensitized. As stated in the subject RICSIL, GE expects that similar cracking may occur in the top guide and core plate of the domestic BWRs which have a similar amount of hot operating time. GE indicated that there are several different configurations of the top guide and core plate assemblies in the GE designed BWRs. The BWR Vessel and Internals Project (BWRVIP), by letter of January 3, 1995, reported GE's evaluation of the safety significance of this cracking event pertaining to the domestic BWRs. The non-proprietary portion of the BWRVIP's letter is provided in the attachment.

The NRC staff will closely monitor the inspections of top guides and core plates in the industry. The staff is evaluating the safety implications of such cracking and will determine if additional generic communication is necessary.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact (one of) the technical contact(s) listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

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* see previous concurrences

OFC	EMCB:DE	SC/EMCB:DE	C/EMCB:DE	PUB:ADM
NAME	WHKoo*	RAHermann*	JRStrosnider	Tech ED
DATE	01/09/95	01/09/95	1/9/95	/ /
OFC	C/OEAB:DORS	C/OGCB:DORS	D/DORS	
NAME	AChaffee	GMarcus	BGrimes	
DATE	/ /	/ /	/ /	

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