The vent valves are contained in the core support shield assembly where the plenum assembly resides. These valves are check valves meant to relieve pressure in the interior of the core support assembly during a large break LOCA, preventing backpressure from reversing coolant flow through the core. These vent valves can be damaged due to mishandling when inserting and removing the plenum. The vent valve components listed above were identified as being susceptible to thermal aging embrittlement, which may lead to cracking. An existing program is in place at each of the B&W-designed units that requires testing and inspection of the vent valve assemblies each refueling outage. The aging management measures provided in these requirements include a provision to visually inspect the valve body and disc seating surfaces. Continuation of the existing vent valve testing and inspection requirements will manage cracking of the vent valve component items that could cause loss of the vent valve function.

Primary (applicable to all plants):

- Plenum cover weldment rib pads
- Plenum cover support flange
- CSS top flange

There are no expansion items for these components.

The potential age-related degradation mechanism for the core clamp region is wear. The purpose of the clamping is to stabilize and significantly restrict rigid body pendulum motion of the core support assembly. Wear at these locations will progress from motions generated by fluid flow once the loss of core clamping is initiated. Note that a one-time physical measurement is to be performed prior to subsequent visual (VT-3) examination.

Primary:

- Upper core barrel (UCB) bolt locking devices (applicable to all plants)

  Expand to:

  - Upper thermal shield (UTS) bolt locking devices (applicable to all plants)
  - Lower thermal shield (LTS) bolt or stud/nut locking devices (applicable to all plants)
  - Surveillance specimen holder tube (SSHT) bolt or stud/nut locking devices (Crystal River Unit 3 (CR-3) and Davis-Besse (DB) only)
  - Lower grid shock pad bolt locking devices (TMI-1 only)

- Lower core barrel (LCB) bolt locking devices (applicable to all plants)

  Expand to:

  - Upper thermal shield (UTS) bolt locking devices (applicable to all plants)
  - Lower thermal shield (LTS) bolt or stud/nut locking devices (applicable to all plants)
  - Surveillance specimen holder tube (SSHT) bolt or stud/nut locking devices (Crystal River Unit 3 (CR-3) and Davis-Besse (DB) only)
  - Lower grid shock pad bolt locking devices (TMI-1 only)

- Flow Distributor (FD) bolt locking devices (applicable to all plants)

  Expand to:

  - Upper thermal shield (UTS) bolt locking devices (applicable to all plants)
  - Lower thermal shield (LTS) bolt or stud/nut locking devices (applicable to all plants)
  - Surveillance specimen holder tube (SSHT) bolt or stud/nut locking devices (Crystal River Unit 3 (CR-3) and Davis-Besse (DB) only)
  - Lower grid shock pad bolt locking devices (TMI-1 only)

Note that the bolts or stud/nuts associated with these locking devices are also examined by volumetric (UT) examination.

- ***Volumetric (UT) Examination***

  Primary:

  - Upper core barrel (UCB) bolts (applicable to all plants)

    Expand to:

    - Upper thermal shield (UTS) bolts (applicable to all plants)
    - Lower thermal shield (LTS) bolts or stud/nuts (applicable to all plants)
    - Surveillance specimen holder tube (SSHT) bolts or stud/nuts (Crystal River Unit 3 (CR-3) and Davis-Besse (DB) only)
    - Lower grid shock pad bolts (TMI-1 only)

  - Lower core barrel (LCB) bolts (applicable to all plants)

    Expand to:

    - Upper thermal shield (UTS) bolts (applicable to all plants)
    - Lower thermal shield (LTS) bolts or stud/nuts (applicable to all plants)
    - Surveillance specimen holder tube (SSHT) bolts or stud/nuts (Crystal River Unit 3 (CR-3) and Davis-Besse (DB) only)
    - Lower grid shock pad bolts (TMI-1 only)

  - Flow Distributor (FD) bolts (applicable to all plants)

    Expand to:

    - Upper thermal shield (UTS) bolts (applicable to all plants)
    - Lower thermal shield (LTS) bolt or stud/nuts (applicable to all plants)
    - Surveillance specimen holder tube (SSHT) bolt or stud/nuts (Crystal River Unit 3 (CR-3) and Davis-Besse (DB) only)
    - Lower grid shock pad bolts (TMI-1 only)

Note that the locking devices associated with these bolts or stud/nuts are also examined by visual (VT-3) examination.

The potential degradation mechanism for the high-strength bolting rings is stress corrosion cracking. For bolting or stud/nuts, this mechanism is best detected using ultrasonic examination techniques.

The upper core barrel bolts are accessible for ultrasonic examination while the core support shield assembly is in the reactor vessel and the plenum is removed. Ultrasonic examination of the upper core barrel bolts can be performed during a normal refueling outage. The lower core barrel bolts and flow distributor bolts are only accessible when the core support shield assembly is removed from the reactor vessel. Some lower core barrel bolts are more difficult to examine and are inaccessible for replacement due to the presence of the core guide blocks mounted on the side of the lower grid assembly.

Primary (applicable to all plants):

- Baffle-to-former (FB) bolts

  Expand to:

  - Baffle-to-baffle (BB) bolts
  - Core barrel-to-former (CBF) bolts

Note that the locking devices associated with these bolts are also examined by visual (VT-3) examination.

Note that even though the baffle-to-baffle (BB) bolts and core barrel-to-former (CBF) bolts are Expansion components, they require an evaluation and not an inspection.

- ***Physical Measurement***

  Primary (applicable to all plants):

  - Plenum cover weldment rib pads
  - Plenum cover support flange
  - CSS top flange

There are no expansion items for these components.

Note: the measurement is performed to determine the differential height of top of the plenum rib pads to the reactor vessel seating surface with all three items inside the reactor vessel, but with the fuel assemblies removed.

Note that these components are subsequently examined by visual (VT-3) examination.

4.3.2 CE Components

Tables 4-2 and 4-5 describe the examination requirements for the PWR internals Primary and Expansion components for CE plants.

The following is a list of the CE Primary and Expansion components by examination technique.

- ***Visual (VT-3) Examination***

  Primary (applicable to all plants):

  - Core support column welds

  There are no expansion items for this component.

  Primary (applicable to bolted plant designs):

  - Core shroud assembly (bolted)

There are no expansion items for this component.

Note that the core shroud assembly (bolted) is examined in order to detect void swelling effects as evidenced by abnormal interaction with fuel assemblies, gaps along high fluence shroud plate joints, vertical displacement of shroud plates near high fluence joint.

  Primary (applicable to all plants with instrument guide tubes in the control element assembly (CEA) shroud assembly):

  - Instrument guide tubes (peripheral)

    Expand to:

    - Remaining instrument guide tubes within the CEA shroud assemblies

- ***Visual (VT-1 and EVT-1) Examinations***

  Primary (applicable to plant designs with core shrouds assembled in two vertical sections):

  - Core shroud assembly (welded)

There are no expansion items for this component.

Note that the core shroud assembly (welded) is examined in order to detect void swelling effects as evidenced by separation between the upper and lower core shroud segments.

  Primary (applicable to plant designs with core shrouds assembled in two vertical sections):

  - Core shroud plate-former plate weld

    Expands to:

    - Remaining axial welds

  Primary (applicable to plant designs with core shrouds assembled with full-height shroud plates)

  - Shroud plates

    Expand to:

    - Remaining axial welds
    - Ribs and rings

  Primary (applicable to all plants):

  - Upper (core support barrel) flange weld

Expands to:

- Lower core support beams
- Core support barrel assembly upper cylinder (including welds)

Primary (applicable to all plants):

- Core support barrel assembly lower cylinder girth welds

  Expands to:

  - Core support barrel assembly lower cylinder axial welds

Note that the core support barrel lower cylinder axial welds are not included as Primary components since they are subject to lower stresses than the girth welds and are thus less susceptible to stress corrosion cracking (SCC or IASCC).

Primary (applicable to all plants with core shrouds assembled with full-height shroud plates):

- Deep beams

There are no expansion items for this component.

Primary (depends on time-limited aging analysis [TLAA]):

- Core support barrel assembly lower flange weld (applicable to all plants)
- Core support plate (applicable to all plants with a core support plate)
- Fuel alignment plate (applicable to all plants with core shrouds assembled with full-height shroud plates)

There are no expansion items for these components.

- ***Volumetric (UT) Examination***

  Primary (applicable to bolted plant designs):

  - Core shroud bolts

    Expand to:

    - Core support column bolts
    - Barrel-shroud bolts

4.3.3 Westinghouse Components

Tables 4-3 and 4-6 describe the examination requirements for the PWR internals Primary and Expansion components for Westinghouse plants.

The following is a list of the Westinghouse Primary and Expansion components by examination technique.

- ***Visual (VT-3) Examination***

  Primary:

  - Baffle-former assembly (applicable to all plants)

- Thermal shield flexures (applicable to all plants with thermal shields)
- Guide plates (cards) (applicable to all plants)

There are no expansion items for these components.

Note that the baffle-former assembly is examined in order to detect void swelling effects as evidenced by abnormal interaction with fuel assemblies, gaps along high fluence baffle joint, vertical displacement of baffle plates near high fluence joint, or broken or damaged edge bolt locking systems along high fluence baffle joint. Also note that the PWROG is conducting a guide card wear project.

Primary:

- Baffle-edge bolts (applicable to all plants with baffle-edge bolts)

There are no expansion items for these components.

Note that the baffle-edge bolts are examined in order to detect lost or broken locking devices, failed or missing bolts, or protrusion of bolt heads.

- ***Visual (VT-1 and EVT-1) Examinations***

Primary (applicable to all plants):

- Upper core barrel flange weld

  Expands to:

  - Lower support column bodies (non cast)

Primary (applicable to all plants):

- Lower core barrel flange weld (alternatively designated as core barrel-to-support plate weld in some plant designs)
- Upper and lower core barrel girth welds

  Expand to:

  - Upper and lower core barrel axial welds

Note that the upper and lower core barrel axial welds are not included as Primary components since they are subject to lower stresses than the girth welds and are thus less susceptible to stress corrosion cracking (SCC or IASCC).

Primary (applicable to all plants):

- Control rod guide tube (CRGT) assembly lower flange welds

  Expand to:

  - Bottom-mounted instrumentation (BMI) column bodies (these components receive a visual (VT-3) examination)
  - Lower support column bodies (cast)
  - Upper core plate

   - Lower support forging or casting

Note that the examination coverage is 100% of outer (accessible) CRGT lower flange weld surfaces and adjacent base metal.

- ***Volumetric (UT) Examination***

  Primary (applicable to all plants):

  – Baffle-former bolts

    Expand to:

    - Lower support column bolts
    - Barrel-former bolts

- ***Physical Measurement***

  Primary (applicable to all plants with 304 stainless steel hold down springs):

  – Internals hold down spring

There are no expansion items for this component.

Table 4-1
B&W plants Primary components

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 2)	Examination Method/Frequency (Note 2)	Examination Coverage
Plenum Cover Assembly & Core Support Shield Assembly Plenum cover weldment rib pads Plenum cover support flange CSS top flange	All plants	Loss of material and associated loss of core clamping pre-load (Wear)	None	One-time physical measurement no later than two refueling outages from the beginning of the license renewal period. Perform subsequent visual (VT-3) examination on the 10-year ISI interval.	Determination of differential height of top of plenum rib pads to reactor vessel seating surface, with plenum in reactor vessel. See Figure 4-1.
Control Rod Guide Tube Assembly CRGT spacer castings	All plants	Cracking (TE), including the detection of fractured spacers or missing screws	None	Visual (VT-3) examination during the next 10-year ISI. Subsequent examinations on the 10-year ISI interval.	Accessible surfaces at each of the 4 screw locations (at every 90°) of 100% of the CRGT spacer castings (limited accessibility). See Figure 4-5.
Core Support Shield Assembly CSS vent valve top retaining ring CSS vent valve bottom retaining ring (Note 1)	All plants	Cracking (TE), including the detection of surface irregularities, such as damaged, fractured material, or missing items	None	Visual (VT-3) examination during the next 10-year ISI. Subsequent examinations on the 10-year ISI interval.	100% of accessible surfaces (see BAW-2248A, page 4.3 and Table 4-1). See Figure 4-11.

Table 4-1
B&W plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 2)	Examination Method/Frequency (Note 2)	Examination Coverage
Core Support Shield Assembly Upper core barrel (UCB) bolts and their locking devices	All plants	Bolts: Cracking (SCC) Locking Devices: Loss of material, damaged, distorted or missing locking devices (Wear or Fatigue damage by failed bolts).	UTS bolts and LTS studs/nuts or bolts and their locking devices SSHT studs/nuts or bolts and their locking devices (CR-3 and DB only) Lower grid shock pad bolts and their locking devices (TMI-1 only)	Volumetric examination (UT) of the bolts within two refueling outages from 1/1/2006 or next 10-year ISI interval, whichever is first. Subsequent examination on the 10-year ISI interval unless an evaluation of the baseline results submitted for NRC staff approval justifies a longer interval between examinations. Visual (VT-3) examination of bolt locking devices on the 10-year ISI interval.	100% of accessible bolts and their locking devices. (Note 3) See Figure 4-7.
Core Barrel Assembly Lower core barrel (LCB) bolts and their locking devices	All plants	Bolt: Cracking (SCC) Locking Devices: Loss of material, damaged, distorted or missing locking devices (Wear or Fatigue damage by failed bolts).	UTS bolts and LTS studs/nuts or bolts and their locking devices SSHT studs/nuts or bolts and their locking devices (CR-3 and DB only) Lower grid shock pad bolts and their locking devices (TMI-1 only)	Volumetric examination (UT) of the bolts during the next 10-year ISI interval from 1/1/2006. Subsequent examination on the 10-year ISI interval unless an evaluation of the baseline results submitted for NRC staff approval justifies a longer interval between examinations. Visual (VT-3) examination of bolt locking devices on the 10-year ISI interval.	100% of accessible bolts and their locking devices (Note 3) See Figure 4-8.

Table 4-1
B&W plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 2)	Examination Method/Frequency (Note 2)	Examination Coverage
Core Barrel Assembly Baffle-to-former bolts	All plants	Cracking (IASCC, IE, Overload) (Note 4)	Baffle-to-baffle bolts, Core barrel-to-former bolts	Baseline volumetric examination (UT) no later than two refueling outages from the beginning of the license renewal period with subsequent examination after 10 additional years.	100% of accessible bolts. (Note 3) See Figure 4-2.
Core Barrel Assembly Baffle plates	All plants	Cracking (IE), including the detection of readily detectable cracking in the baffle plates	Core barrel cylinder (including vertical and circumferential seam welds), Former plates	Visual (VT-3) examination during the next 10-year ISI. Subsequent examinations on the 10-year ISI interval.	100% of the accessible surface within 1 inch around each flow and bolt hole. See Figure 4-2.
Core Barrel Assembly Locking devices, including locking welds, of baffle-to-former bolts and internal baffle-to-baffle bolts	All plants	Cracking (IASCC, IE, Overload), including the detection of missing, non-functional, or removed locking devices or welds	Locking devices, including locking welds, for the external baffle-to-baffle bolts and Core barrel-to-former bolts	Visual (VT-3) examination during the next 10-year ISI. Subsequent examinations on the 10-year ISI interval.	100% of accessible baffle-to-former and internal baffle-to-baffle bolt locking devices. (Note 3) See Figure 4-2.

Table 4-1
B&W plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 2)	Examination Method/Frequency (Note 2)	Examination Coverage
Flow Distributor Assembly Flow distributor (FD) bolts and their locking devices	All plants	Bolt: Cracking (SCC) Locking Devices: Loss of material, damaged or distorted or missing locking devices (Wear or Fatigue damage by failed bolts).	UTS bolts and LTS studs/nuts or bolts and their locking devices. SSHT studs/nuts or bolts and their locking devices (CR-3 and DB only) Lower grid shock pad bolts and their locking devices (TMI-1 only)	Volumetric examination (UT) of the bolts during the next 10-year ISI interval from 1/1/2006. Subsequent examination on the 10-year ISI interval unless an evaluation of the baseline results, submitted for NRC staff approval, justifies a longer interval between examinations. Visual (VT-3) examination of bolt locking devices on the 10-year ISI interval.	100% of accessible bolts and their locking devices. (Note 3) See Figure 4-8.
Lower Grid Assembly Alloy X-750 dowel-to-guide block welds	All plants	Cracking (SCC), including the detection of separated or missing locking welds, or missing dowels	Alloy X-750 dowel locking welds to the upper and lower grid fuel assembly support pads.	Initial visual (VT-3) examination no later than two refueling outages from the beginning of the license renewal period. Subsequent examinations on the 10-year ISI interval.	Accessible surfaces of 100% of the 24 dowel-to-guide block welds. See Figure 4-4.
Incore Monitoring Instrumentation (IMI) Guide Tube Assembly IMI guide tube spiders IMI guide tube spider-to-lower grid rib section welds	All plants	Cracking (TE/IE), including the detection of fractured or missing spider arms or, Cracking (IE), including separation of spider arms from the lower grid rib section at the weld	Lower grid fuel assembly support pad items: pad, pad-to-rib section welds, Alloy X-750 dowel, cap screw, and their locking welds (Note: the pads, dowels, and cap screws are included because of IE of the welds)	Initial visual (VT-3) examination no later than two refueling outages from the beginning of the license renewal period. Subsequent examinations on the 10-year ISI interval.	100% of top surfaces of 52 spider castings and welds to the adjacent lower grid rib section. See Figures 4-3 and 4-6.

Notes to Table 4-1:

1. A verification of the operation of each vent valve shall also be performed through manual actuation of the valve. Verify that the valves are not stuck in the open position and that no abnormal degradation has occurred. Examine the valves for evidence of scratches, pitting, embedded particles, leakage of the seating surfaces, cracking of lock welds and locking cups, jack screws for proper position, and wear. The frequency is defined in each unit's technical specifications or in their pump and valve inservice test programs (see BAW-2248A, page 4-3 and Table 4-1[18]).
2. Examination acceptance criteria and expansion criteria for the B&W components are in Table 5-1.
3. A minimum of 75% of the total population (examined + unexamined), including coverage consistent with the Expansion criteria in Table 5-1, must be examined for inspection credit.
4. The primary aging degradation mechanisms for loss of joint tightness for this item are IC and ISR. Fatigue and Wear, which can also lead to cracking, are secondary aging degradation mechanisms after significant stress relaxation and loss of preload has occurred due to IC/ISR. Bolt stress relaxation cannot readily be inspected by NDE. Only bolt cracking is inspected by UT inspection. The effect of loss of joint tightness on the functionality will be addressed by analysis of the core barrel assembly, which will be performed to address Applicant/Licensee action item 6 in the SE [27].

Table 4-2
CE plants Primary components

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Shroud Assembly (Bolted) Core shroud bolts	Bolted plant designs	Cracking (IASCC, Fatigue) Aging Management (IE and ISR) (Note 2)	Core support column bolts, Barrel-shroud bolts	Baseline volumetric (UT) examination between 25 and 35 EFPY, with subsequent examination on a ten-year interval.	100% of accessible bolts (see Note 3). Heads are accessible from the core side. UT accessibility may be affected by complexity of head and locking device designs. See Figure 4-24.
Core Shroud Assembly (Welded) Core shroud plate-former plate weld	Plant designs with core shrouds assembled in two vertical sections	Cracking (IASCC) Aging Management (IE) (Note 2)	Remaining axial welds	Enhanced visual (EVT-1) examination no later than 2 refueling outages from the beginning of the license renewal period and subsequent examination on a ten-year interval.	Axial and horizontal weld seams at the core shroud re-entrant corners as visible from the core side of the shroud, within six inches of central flange and horizontal stiffeners. See Figures 4-12 and 4-14.
Core Shroud Assembly (Welded) Shroud plates	Plant designs with core shrouds assembled with full-height shroud plates	Cracking (IASCC) Aging Management (IE) (Note 2)	Remaining axial welds, Ribs and rings	Enhanced visual (EVT-1) examination no later than 2 refueling outages from the beginning of the license renewal period and subsequent examination on a ten-year interval.	Axial weld seams at the core shroud re-entrant corners, at the core mid-plane (± three feet in height) as visible from the core side of the shroud. See Figure 4-13.

Table 4-2
CE plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Shroud Assembly (Bolted) Assembly	Bolted plant designs	Distortion (Void Swelling), including: • Abnormal interaction with fuel assemblies • Gaps along high fluence shroud plate joints • Vertical displacement of shroud plates near high fluence joint Aging Management (IE)	None	Visual (VT-3) examination no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examinations on a ten-year interval.	Core side surfaces as indicated. See Figures 4-25 and 4-26.
Core Shroud Assembly (Welded) Assembly	Plant designs with core shrouds assembled in two vertical sections	Distortion (Void Swelling), as evidenced by separation between the upper and lower core shroud segments Aging Management (IE)	None	Visual (VT-1) examination no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examinations on a ten-year interval.	If a gap exists, make three to five measurements of gap opening from the core side at the core shroud re-entrant corners. Then, evaluate the swelling on a plant-specific basis to determine frequency and method for additional examinations. See Figures 4-12 and 4-14.

Table 4-2
CE plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Support Barrel Assembly Upper (core support barrel) flange weld	All plants	Cracking (SCC)	Lower core support beams Core support barrel assembly upper cylinder Upper core barrel flange	Enhanced visual (EVT-1) examination no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examinations on a ten-year interval.	100% of the accessible surfaces of the upper flange weld (Note 4). See Figure 4-15.
Core Support Barrel Assembly Lower cylinder girth welds	All plants	Cracking (SCC, IASCC) Aging Management (IE)	Lower cylinder axial welds	Enhanced visual (EVT-1) examination no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examinations on a ten-year interval.	100% of the accessible surfaces of the lower cylinder welds (Note 4). See Figure 4-15
Lower Support Structure Core support column welds	All plants	Cracking (SCC, IASCC, Fatigue including damaged or fractured material) Aging Management (IE, TE)	None	Visual (VT-3) examination no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examinations on a ten-year interval.	100% of the accessible surfaces of the core support column welds (Note 5). See Figures 4-16 and 4-31

Table 4-2
CE plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Support Barrel Assembly Lower flange weld	All plants	Cracking (Fatigue)	None	If fatigue life cannot be demonstrated by time-limited aging analysis (TLAA), enhanced visual (EVT-1) examination, no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examination on a ten-year interval.	Examination coverage to be defined by evaluation to determine the potential location and extent of fatigue cracking. See Figures 4-15 and 4-16.
Lower Support Structure Core support plate	All plants with a core support plate	Cracking (Fatigue) Aging Management (IE)	None	If fatigue life cannot be demonstrated by time-limited aging analysis (TLAA), enhanced visual (EVT-1) examination, no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examination on a ten-year interval.	Examination coverage to be defined by evaluation to determine the potential location and extent of fatigue cracking. See Figure 4-16.
Upper Internals Assembly Fuel alignment plate	All plants with core shrouds assembled with full-height shroud plates	Cracking (Fatigue)	None	If fatigue life cannot be demonstrated by time-limited aging analysis (TLAA), enhanced visual (EVT-1) examination, no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examination on a ten-year interval.	Examination coverage to be defined by evaluation to determine the potential location and extent of fatigue cracking. See Figure 4-17.

Table 4-2
CE plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Control Element Assembly Instrument guide tubes	All plants with instrument guide tubes in the CEA shroud assembly	Cracking (SCC, Fatigue) that results in missing supports or separation at the welded joint between the tubes and supports	Remaining instrument guide tubes within the CEA shroud assemblies	Visual (VT-3) examination, no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examination on a ten-year interval. Plant-specific component integrity assessments may be required if degradation is detected and remedial action is needed.	100% of tubes in peripheral CEA shroud assemblies (i.e., those adjacent to the perimeter of the fuel alignment plate). See Figure 4-18.
Lower Support Structure Deep beams	All plants with core shrouds assembled with full-height shroud plates	Cracking (Fatigue) that results in a detectable surface-breaking indication in the welds or beams Aging Management (IE)	None	Enhanced visual (EVT-1) examination, no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examination on a ten-year interval, if adequacy of remaining fatigue life cannot be demonstrated.	Examine beam-to-beam welds, in the axial elevation from the beam top surface to four inches below. See Figure 4-19.

Note to Table 4-2:

1. Examination acceptance criteria and expansion criteria for the CE components are in Table 5-2.
2. Void swelling effects on this component is managed through management of void swelling on the entire core shroud assembly.
3. A minimum of 75% of the total population (examined + unexamined), including coverage consistent with the Expansion criteria in Table 5-2, must be examined for inspection credit.
4. A minimum of 75% of the total weld length (examined + unexamined), including coverage consistent with the Expansion criteria in Table 5-2, must be examined from either the inner or outer diameter for inspection credit.
5. A minimum of 75% of the total population of core support column welds.

Table 4-3
Westinghouse plants Primary components

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Control Rod Guide Tube Assembly Guide plates (cards)	All plants	Loss of Material (Wear)	None	Visual (VT-3) examination no later than 2 refueling outages from the beginning of the license renewal period, and no earlier than two refueling outages prior to the start of the license renewal period. Subsequent examinations are required on a ten-year interval.	20% examination of the number of CRGT assemblies, with all guide cards within each selected CRGT assembly examined. See Figure 4-20
Control Rod Guide Tube Assembly Lower flange welds	All plants	Cracking (SCC, Fatigue) Aging Management (IE and TE)	Bottom-mounted instrumentation (BMI) column bodies, Lower support column bodies (cast) Upper core plate Lower support forging/casting	Enhanced visual (EVT-1) examination to determine the presence of crack-like surface flaws in flange welds no later than 2 refueling outages from the beginning of the license renewal period and subsequent examination on a ten-year interval.	100% of outer (accessible) CRGT lower flange weld surfaces and adjacent base metal on the individual periphery CRGT assemblies. (Note 2) See Figure 4-21.
Core Barrel Assembly Upper core barrel flange weld	All plants	Cracking (SCC)	Lower support column bodies (non cast) Core barrel outlet nozzle welds	Periodic enhanced visual (EVT-1) examination, no later than 2 refueling outages from the beginning of the license renewal period and subsequent examination on a ten-year interval.	100% of one side of the accessible surfaces of the selected weld and adjacent base metal (Note 4). See Figure 4-22.
Core Barrel Assembly Upper and lower core barrel cylinder girth welds	All plants	Cracking (SCC, IASCC, Fatigue)	Upper and lower core barrel cylinder axial welds	Periodic enhanced visual (EVT-1) examination, no later than 2 refueling outages from the beginning of the license renewal period and subsequent examination on a ten-year interval.	100% of one side of the accessible surfaces of the selected weld and adjacent base metal (Note 4). See Figure 4-22

Table 4-3
Westinghouse plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Barrel Assembly Lower core barrel flange weld (Note 5)	All plants	Cracking (SCC, Fatigue)	None	Periodic enhanced visual (EVT-1) examination, no later than 2 refueling outages from the beginning of the license renewal period and subsequent examination on a ten-year interval.	100% of one side of the accessible surfaces of the selected weld and adjacent base metal (Note 4).
Baffle-Former Assembly Baffle-edge bolts	All plants with baffle-edge bolts	Cracking (IASCC, Fatigue) that results in •Lost or broken locking devices •Failed or missing bolts •Protrusion of bolt heads Aging Management (IE and ISR) (Note 6)	None	Visual (VT-3) examination, with baseline examination between 20 and 40 EFPY and subsequent examinations on a ten-year interval.	Bolts and locking devices on high fluence seams. 100% of components accessible from core side (Note 3). See Figure 4-23.
Baffle-Former Assembly Baffle-former bolts	All plants	Cracking (IASCC, Fatigue) Aging Management (IE and ISR) (Note 6)	Lower support column bolts, Barrel-former bolts	Baseline volumetric (UT) examination between 25 and 35 EFPY, with subsequent examination on a ten-year interval.	100% of accessible bolts (Note 3). Heads accessible from the core side. UT accessibility may be affected by complexity of head and locking device designs. See Figures 4-23 and 4-24.

Table 4-3
Westinghouse plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Baffle-Former Assembly Assembly (Includes: Baffle plates, baffle edge bolts and indirect effects of void swelling in former plates)	All plants	Distortion (Void Swelling), or Cracking (IASCC) that results in •Abnormal interaction with fuel assemblies •Gaps along high fluence baffle joint •Vertical displacement of baffle plates near high fluence joint •Broken or damaged edge bolt locking systems along high fluence baffle joint	None	Visual (VT-3) examination to check for evidence of distortion, with baseline examination between 20 and 40 EFPY and subsequent examinations on a ten-year interval.	Core side surface as indicated. See Figures 4-24, 4-25, 4-26 and 4-27.
Alignment and Interfacing Components Internals hold down spring	All plants with 304 stainless steel hold down springs	Distortion (Loss of Load) Note: This mechanism was not strictly identified in the original list of age-related degradation mechanisms [7].	None	Direct measurement of spring height within three cycles of the beginning of the license renewal period. If the first set of measurements is not sufficient to determine life, spring height measurements must be taken during the next two outages, in order to extrapolate the expected spring height to 60 years.	Measurements should be taken at several points around the circumference of the spring, with a statistically adequate number of measurements at each point to minimize uncertainty. See Figure 4-28.

Table 4-3
Westinghouse plants Primary components (continued)

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Thermal Shield Assembly Thermal shield flexures	All plants with thermal shields	Cracking (Fatigue) or Loss of Material (Wear) that results in thermal shield flexures excessive wear, fracture, or complete separation	None	Visual (VT-3) no later than 2 refueling outages from the beginning of the license renewal period. Subsequent examinations on a ten-year interval.	100% of thermal shield flexures. See Figures 4-29 and 4-36.

Notes to Table 4-3:

1. Examination acceptance criteria and expansion criteria for the Westinghouse components are in Table 5-3.
2. A minimum of 75% of the total identified sample population must be examined.
3. A minimum of 75% of the total population (examined + unexamined), including coverage consistent with the Expansion criteria in Table 5-3, must be examined for inspection credit.
4. A minimum of 75% of the total weld length (examined + unexamined), including coverage consistent with the Expansion criteria in Table 5-3, must be examined from either the inner or outer diameter for inspection credit.
5. The lower core barrel flange weld may be alternatively designated as the core barrel-to-support plate weld in some Westinghouse plant designs.
6. Void swelling effects on this component is managed through management of void swelling on the entire baffle-former assembly.

Table 4-4
B&W plants Expansion components

Item	Applicability	Effect (Mechanism)	Primary Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Upper Grid Assembly Alloy X-750 dowel-to-upper grid fuel assembly support pad welds	All plants (except DB)	Cracking (SCC), including the detection of separated or missing locking welds, or missing dowels	Alloy X-750 dowel-to-guide block welds	Visual (VT-3) examination. Subsequent examinations on the 10-year ISI interval unless an applicant/licensee provides an evaluation for NRC staff approval that justifies a longer interval between inspections.	Accessible surfaces of 100% of the dowel locking welds. See Figure 4-6 (i.e., these are similar to the lower grid fuel assembly support pads).
Core Barrel Assembly Upper thermal shield (UTS) bolts and their locking devices	All plants	Bolt or Stud/Nut: Cracking (SCC) Locking Devices: Loss of material, damaged, distorted or missing locking devices (Wear or Fatigue damage by failed bolts).	UCB, LCB or FD bolts and their locking devices	Bolt or Stud/Nut: Volumetric examination (UT). Locking Devices: Visual (VT-3) examination Subsequent examinations on the 10-year ISI interval unless an applicant/licensee provides an evaluation for NRC staff approval that justifies a longer interval between inspections.	100% of accessible bolts or studs/nuts and their locking devices (Note 2). See Figure 4-7.
Core Barrel Assembly Surveillance specimen holder tube (SSHT) studs/nuts (CR-3) or bolts (DB) and their locking devices	CR-3, DB				
Core Barrel Assembly Core barrel cylinder (including vertical and circumferential seam welds) Former plates	All plants	Cracking (IE), including readily detectable cracking	Baffle plates	No examination requirements. Justify by evaluation or by replacement.	Inaccessible. See Figure 4-2.

Table 4-4
B&W plants Expansion components (continued)

Item	Applicability	Effect (Mechanism)	Primary Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Barrel Assembly Baffle-to-baffle bolts Core barrel-to-former bolts	All plants	Cracking (IASCC, IE, Overload) (Note 3)	Baffle-to-former bolts	Internal baffle-to-baffle bolts: No examination requirements, Justify by evaluation or by replacement.	An acceptable examination technique currently not available. See Figure 4-2.
				External baffle-to-baffle bolts, core barrel-to-former bolts: No examination requirements. Justify by evaluation or by replacement.	Inaccessible. See Figure 4-2.
Core Barrel Assembly Locking devices, including locking welds, for the external baffle-to-baffle bolts and core barrel-to-former bolts	All plants	Cracking (IASCC, IE)	Locking devices, including locking welds, of baffle-to-former bolts or internal baffle-to-baffle bolts	No examination requirements. Justify by evaluation or by replacement.	Inaccessible. See Figure 4-2.
Lower Grid Assembly Lower grid fuel assembly support pad items: pad, pad-to-rib section welds, Alloy X-750 dowel, cap screw, and their locking welds (Note: the pads, dowels and cap screws are included because of IE of the welds)	All plants	Cracking (IE), including the detection of separated or missing welds, missing support pads, dowels, cap screws and locking welds, or misalignment of the support pads	IMI guide tube spiders and spider-to-lower grid rib section welds	Visual (VT-3) examination. Subsequent examinations on the 10-year ISI interval unless an applicant/licensee provides an evaluation for NRC staff approval that justifies a longer interval between inspections.	Accessible surfaces of the pads, dowels, and cap screws, and associated welds in 100% of the lower grid fuel assembly support pads. See Figure 4-6.

Table 4-4
B&W plants Expansion components (continued)

Item	Applicability	Effect (Mechanism)	Primary Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Lower Grid Assembly Alloy X-750 dowel-to-lower grid fuel assembly support pad welds	All plants	Cracking (SCC), including the detection of separated or missing locking welds, or missing dowels	Alloy X-750 dowel-to-guide block welds	Visual (VT-3) examination. Subsequent examinations on the 10-year ISI interval unless an applicant/licensee provides an evaluation for NRC staff approval that justifies a longer interval between inspections.	Accessible surfaces of 100% of the support pad dowel locking welds. See Figure 4-6.
Lower Grid Assembly Lower grid shock pad bolts and their locking devices	TMI-1	Bolts: Cracking (SCC) Locking Devices: Loss of material, damaged, distorted or missing locking devices (Wear or Fatigue damage by failed bolts).	UCB, LCB or FD bolts and their locking devices	Bolt: Volumetric examination (UT). Locking Devices: Visual (VT-3) examination. Subsequent examinations on the 10-year ISI interval unless an applicant/licensee provides an evaluation for NRC staff approval that justifies a longer interval between inspections.	100% of accessible bolts and their locking devices. (Note 2) See Figure 4-4.
Lower Grid Assembly Lower thermal shield (LTS) bolts (ANO-1, DB and TMI-1) or studs/nuts (ONS, CR-3) and their locking devices	All plants	Bolts or Studs/Nuts: Cracking (SCC) Locking Devices: Loss of material, damaged, distorted or missing locking devices (Wear or Fatigue damage by failed bolts).	UCB,LCB or FD bolts and their locking devices	Bolt or Stud/Nut: Volumetric examination (UT). Locking Devices: Visual (VT-3) examination. Subsequent examinations on the 10-year ISI interval unless an applicant/licensee provides an evaluation for NRC staff approval that justifies a longer interval between inspections.	100% of accessible bolts and their locking devices. (Note 2) See Figure 4-8.

Notes to Table 4-4:

1. Examination acceptance criteria and expansion criteria for the B&W components are in Table 5-1.
2. A minimum of 75% of the total population (examined + unexamined) must be examined for inspection credit.
3. The primary aging degradation mechanisms for loss of joint tightness for these items are IC and ISR. Fatigue and Wear, which can also lead to cracking, are secondary aging degradation mechanisms after significant stress relaxation and loss of preload has occurred due to IC/ISR. Bolt stress relaxation cannot readily be inspected by NDE. Only bolt cracking could be inspected by UT inspection if it were possible for these bolts. Therefore, the effects of loss of joint tightness and/or cracking on the functionality of these bolts relative to the entire core barrel assembly will be addressed by analysis of the core barrel assembly, which will be performed to address Applicant/Licensee action item 6 of the SE [27].

Table 4-5
CE plants Expansion components

Item	Applicability	Effect (Mechanism)	Primary Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Shroud Assembly (Bolted) Barrel-shroud bolts	Bolted plant designs	Cracking (IASCC, Fatigue) Aging Management (IE and ISR)	Core shroud bolts	Volumetric (UT) examination. Re-inspection every 10 years following initial inspection.	100% (or as supported by plant-specific justification; Note 2) of barrel-shroud and guide lug insert bolts with neutron fluence exposures > 3 displacements per atom (dpa). See Figure 4-23.
Core Support Barrel Assembly Lower core barrel flange	All plants	Cracking (SCC, Fatigue)	Upper (core support barrel) flange weld	Enhanced visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of accessible welds and adjacent base metal (Note 2). See Figure 4-15.
Core Support Barrel Assembly Upper cylinder (including welds)	All plants	Cracking (SCC) Aging Management (IE)	Upper (core support barrel) flange weld	Enhanced visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of accessible surfaces of the welds and adjacent base metal (Note 2). See Figure 4-15.
Core Support Barrel Assembly Upper core barrel flange	All plants	Cracking (SCC)	Upper (core support barrel) flange weld	Enhanced visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of accessible bottom surface of the flange (Note 2). See Figure 4-15.

Table 4-5
CE plants Expansion components (continued)

Item	Applicability	Effect (Mechanism)	Primary Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Support Barrel Assembly Core barrel assembly axial welds	All plants	Cracking (SCC)	Core barrel assembly girth welds	Enhanced visual (EVT-1) examination, with initial and subsequent examinations dependent on the results of core barrel assembly girth weld examinations.	100% of one side of the accessible weld and adjacent base metal surfaces for the weld with the highest calculated operating stress. See Figure 4-15.
Lower Support Structure Lower core support beams	All plants except those with core shrouds assembled with full-height shroud plates	Cracking (SCC, Fatigue) including damaged or fractured material	Upper (core support barrel) flange weld	Visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of accessible surfaces (Note 2). See Figures 4-16 and 4-31.
Core Shroud Assembly (Bolted) Core support column bolts	Bolted plant designs	Cracking (IASCC, Fatigue) Aging Management (IE)	Core shroud bolts	Ultrasonic (UT) examination. Re-inspection every 10 years following initial inspection.	100% (or as supported by plant-specific analysis) of core support column bolts with neutron fluence exposures > 3 dpa (Note 2). See Figures 4-16 and 4-33.

Table 4-5
CE plants Expansion components (continued)

Item	Applicability	Effect (Mechanism)	Primary Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Shroud Assembly (Welded) Remaining axial welds, Ribs and rings	Plant designs with core shrouds assembled with full-height shroud plates	Cracking (IASCC) Aging Management (IE)	Shroud plates of welded core shroud assemblies	Enhanced visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	Axial weld seams other than the core shroud re-entrant corner welds at the core mid-plane, plus ribs and rings. See Figure 4-13.
Control Element Assembly Remaining instrument guide tubes	All plants with instrument guide tubes in the CEA shroud assembly	Cracking (SCC, Fatigue) that results in missing supports or separation at the welded joint between the tubes and supports.	Peripheral instrument guide tubes within the CEA shroud assemblies	Visual (VT-3) examination. Re-inspection every 10 years following initial inspection.	100% of tubes in CEA shroud assemblies (Note 2). See Figure 4-18.

Notes to Table 4-5:

1. Examination acceptance criteria and expansion criteria for the CE components are in Table 5-2.
2. A minimum of 75% coverage of the entire examination area or volume, or a minimum sample size of 75% of the total population of like components of the examination is required (including both the accessible and inaccessible portions).

Table 4-6
Westinghouse plants Expansion components

Item	Applicability	Effect (Mechanism)	Primary Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Upper Internals Assembly Upper core plate	All plants	Cracking (Fatigue, Wear)	CRGT lower flange weld	Enhanced visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of accessible surfaces (Note 2).
Lower Internals Assembly Lower support forging or castings	All plants	Cracking Aging Management (TE in Casting)	CRGT lower flange weld	Enhanced visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of accessible surfaces (Note 2). See Figure 4-33.
Core Barrel Assembly Barrel-former bolts	All plants	Cracking (IASCC, Fatigue) Aging Management (IE, Void Swelling and ISR)	Baffle-former bolts	Volumetric (UT) examination. Re-inspection every 10 years following initial inspection.	100% of accessible bolts. Accessibility may be limited by presence of thermal shields or neutron pads (Note 2). See Figure 4-23.
Lower Support Assembly Lower support column bolts	All plants	Cracking (IASCC, Fatigue) Aging Management (IE and ISR)	Baffle-former bolts	Volumetric (UT) examination. Re-inspection every 10 years following initial inspection.	100% of accessible bolts or as supported by plant-specific justification (Note 2). See Figures 4-32 and 4-33.

Table 4-6
Westinghouse plants Expansion components (continued)

Item	Applicability	Effect (Mechanism)	Primary Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Core Barrel Assembly Core barrel outlet nozzle welds	All plants	Cracking (SCC, Fatigue) Aging Management (IE of lower sections)	Upper core barrel flange weld	Enhanced visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of one side of the accessible surfaces of the selected weld and adjacent base metal (Note 2). See Figure 4-22.
Core Barrel Assembly Upper and lower core barrel cylinder axial welds	All plants	Cracking (SCC, IASCC) Aging Management (IE)	Upper and lower core barrel cylinder girth welds	Enhanced visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of one side of the accessible surfaces of the selected weld and adjacent base metal (Note 2). See Figure 4-22.
Lower Support Assembly Lower support column bodies (non cast)	All plants	Cracking (IASCC) Aging Management (IE)	Upper core barrel flange weld	Enhanced visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of accessible surfaces (Note 2). See Figure 4-34.
Lower Support Assembly Lower support column bodies (cast)	All plants	Cracking (IASCC) including the detection of fractured support columns Aging Management (IE)	Control rod guide tube (CRGT) lower flanges	Visual (EVT-1) examination. Re-inspection every 10 years following initial inspection.	100% of accessible support columns (Note 2). See Figure 4-34.

Table 4-6
Westinghouse plants Expansion components (continued)

Item	Applicability	Effect (Mechanism)	Primary Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Bottom Mounted Instrumentation System Bottom-mounted instrumentation (BMI) column bodies	All plants	Cracking (Fatigue) including the detection of completely fractured column bodies Aging Management (IE)	Control rod guide tube (CRGT) lower flanges	Visual (VT-3) examination of BMI column bodies as indicated by difficulty of insertion/withdrawal of flux thimbles. Re-inspection every 10 years following initial inspection. Flux thimble insertion/withdrawal to be monitored at each inspection interval.	100% of BMI column bodies for which difficulty is detected during flux thimble insertion/withdrawal. See Figure 4-35.

Notes to Table 4-6:

1. Examination acceptance criteria and expansion criteria for the Westinghouse components are in Table 5-3.
2. A minimum of 75% coverage of the entire examination area or volume, or a minimum sample size of 75% of the total population of like components of the examination is required (including both the accessible and inaccessible portions).

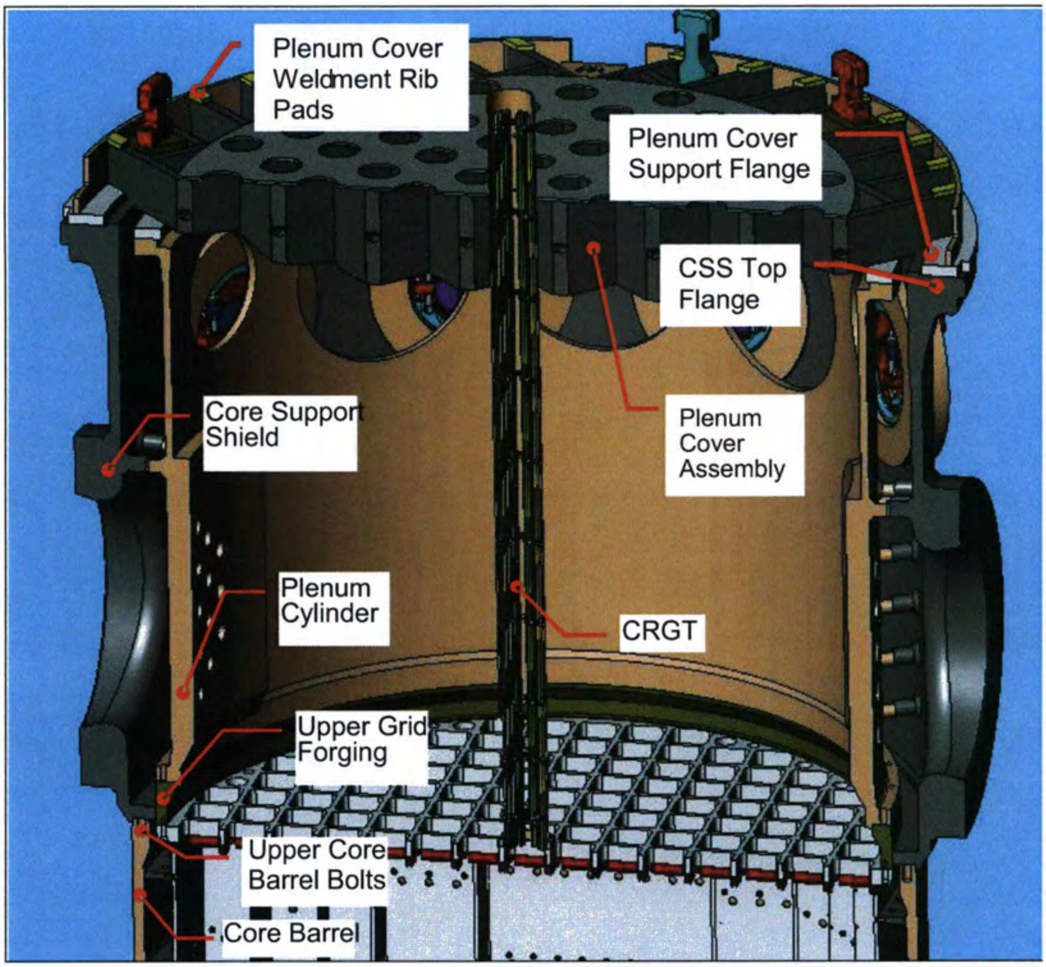


Figure 4-1
Typical upper internals arrangement for B&W-designed PWRs

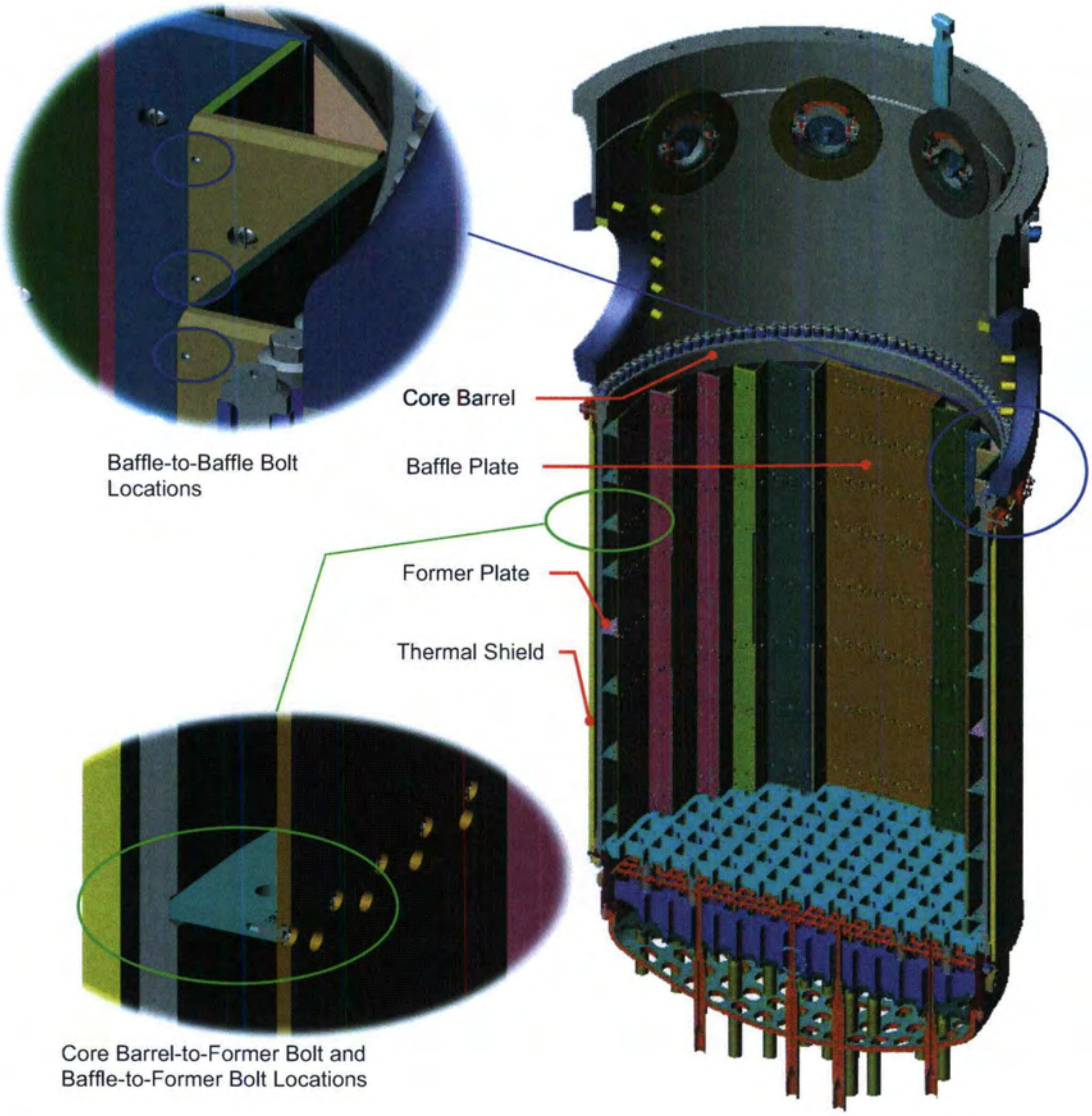


Figure 4-2
Typical internals core barrel assembly for B&W-designed PWRs

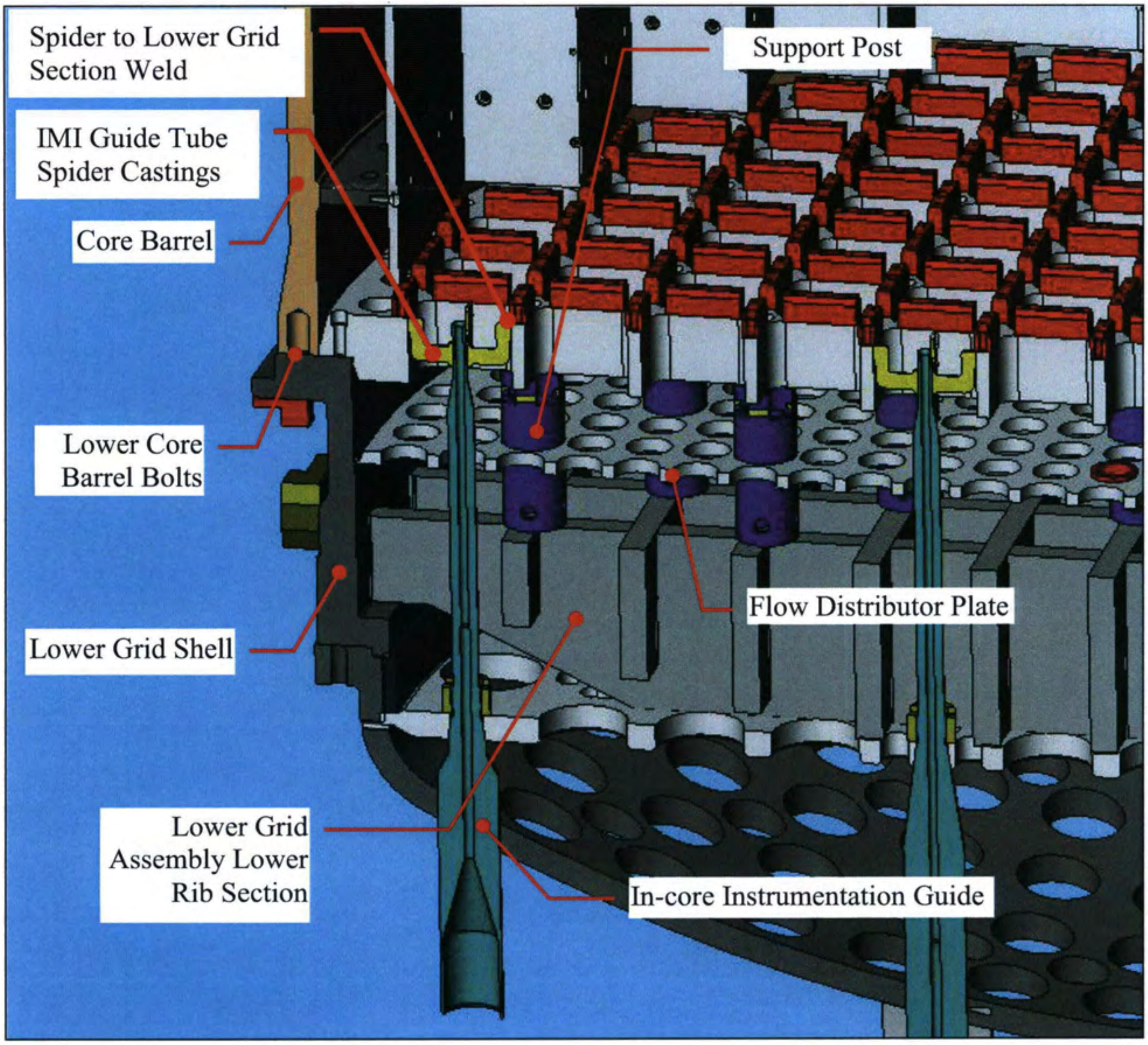


Figure 4-3
Typical lower internals arrangement for B&W-designed PWRs

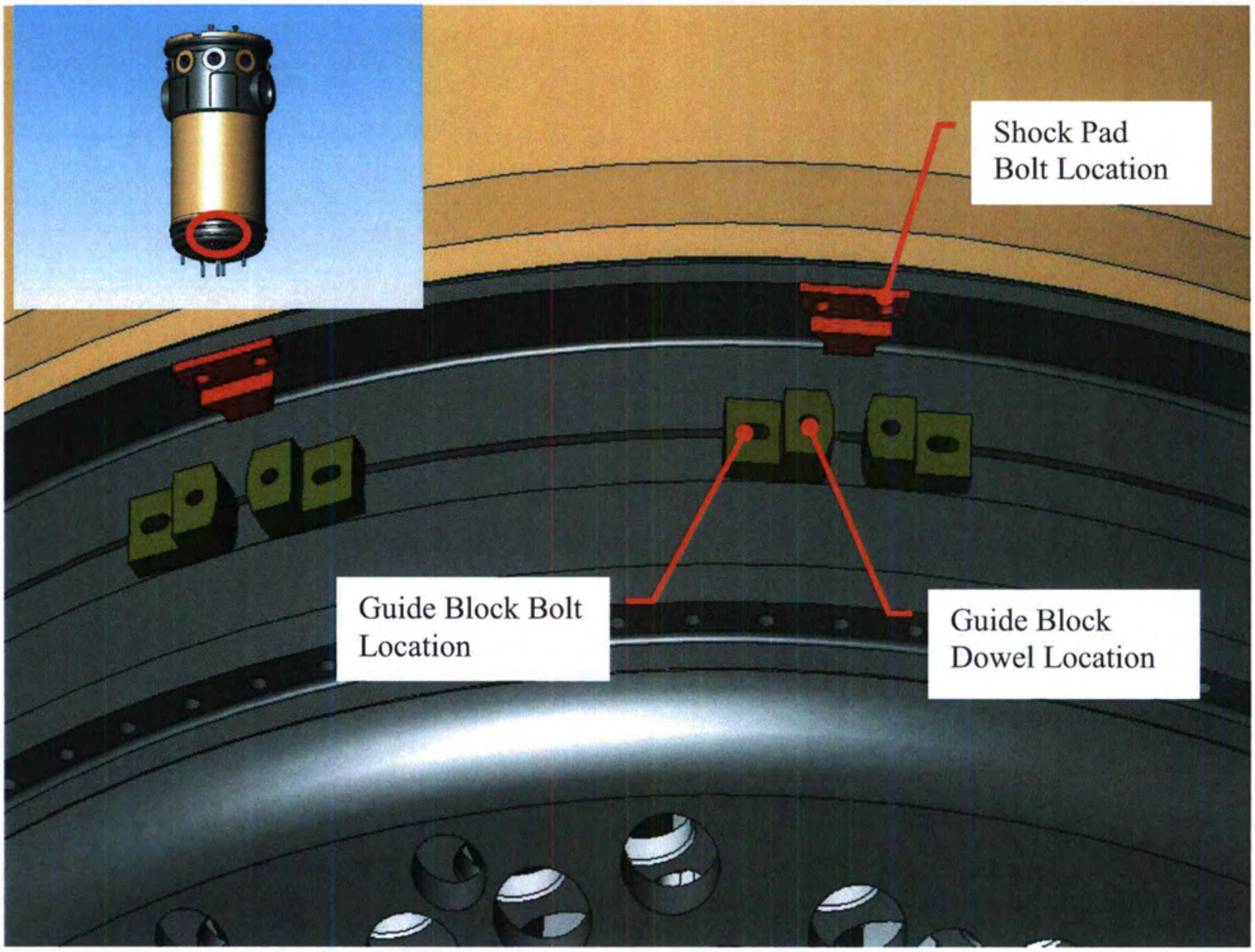


Figure 4-4
Typical guide block and shock pad locations for B&W-designed PWRs

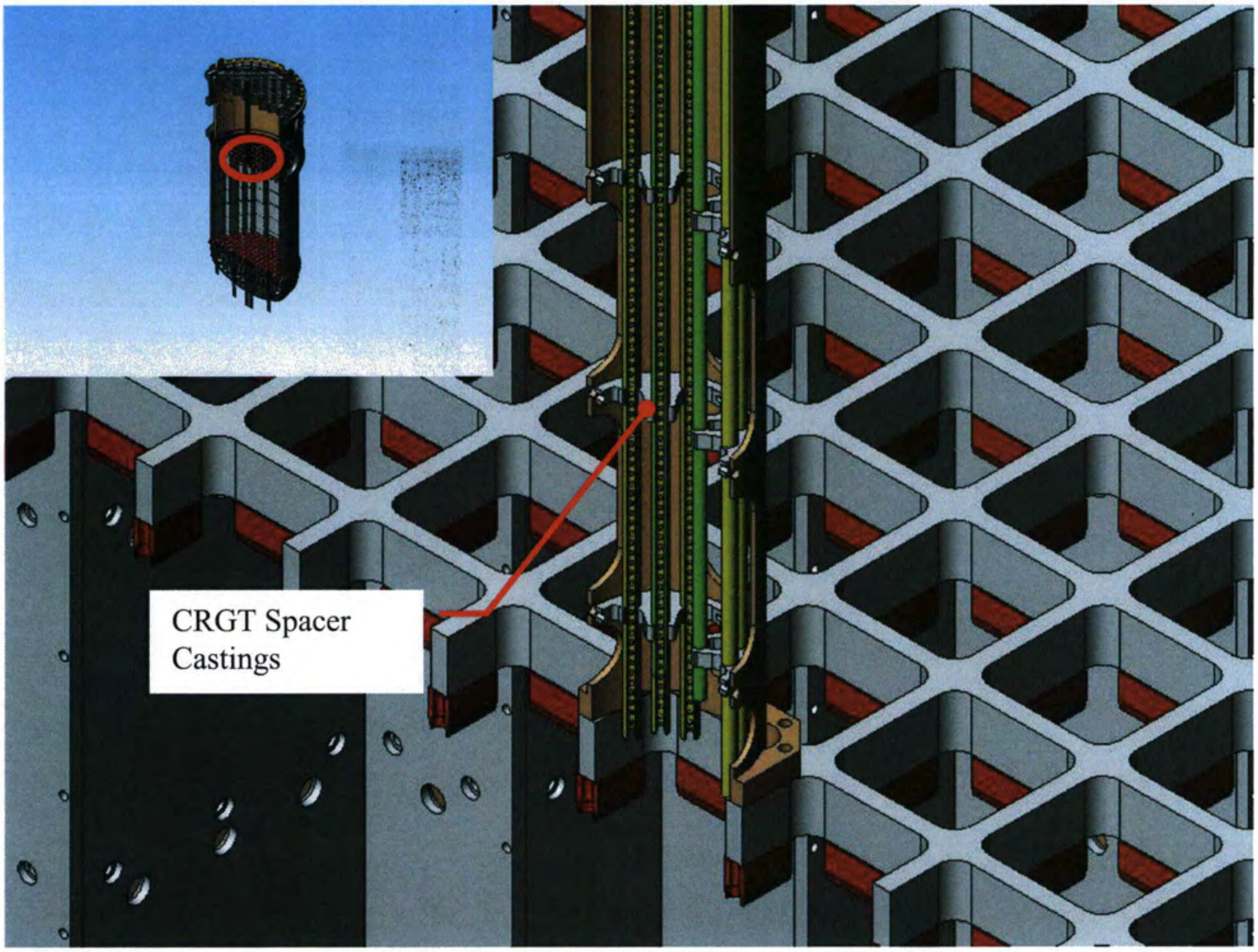


Figure 4-5
Typical control rod guide tube (CRGT) for B&W-designed PWRs (one of 69 CRGTs shown)

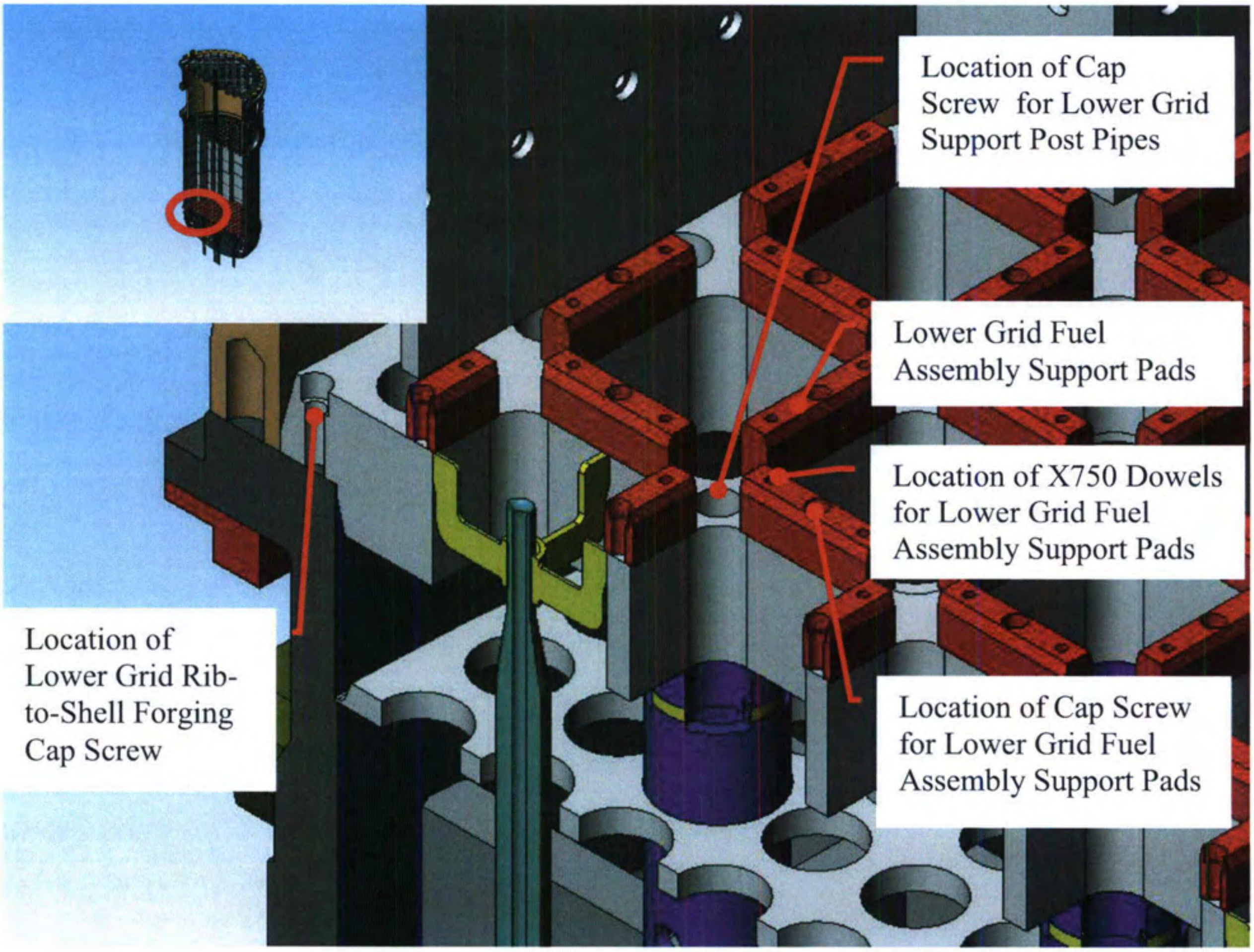


Figure 4-6
Typical lower grid assembly and fuel assembly support pads for B&W-designed PWRs

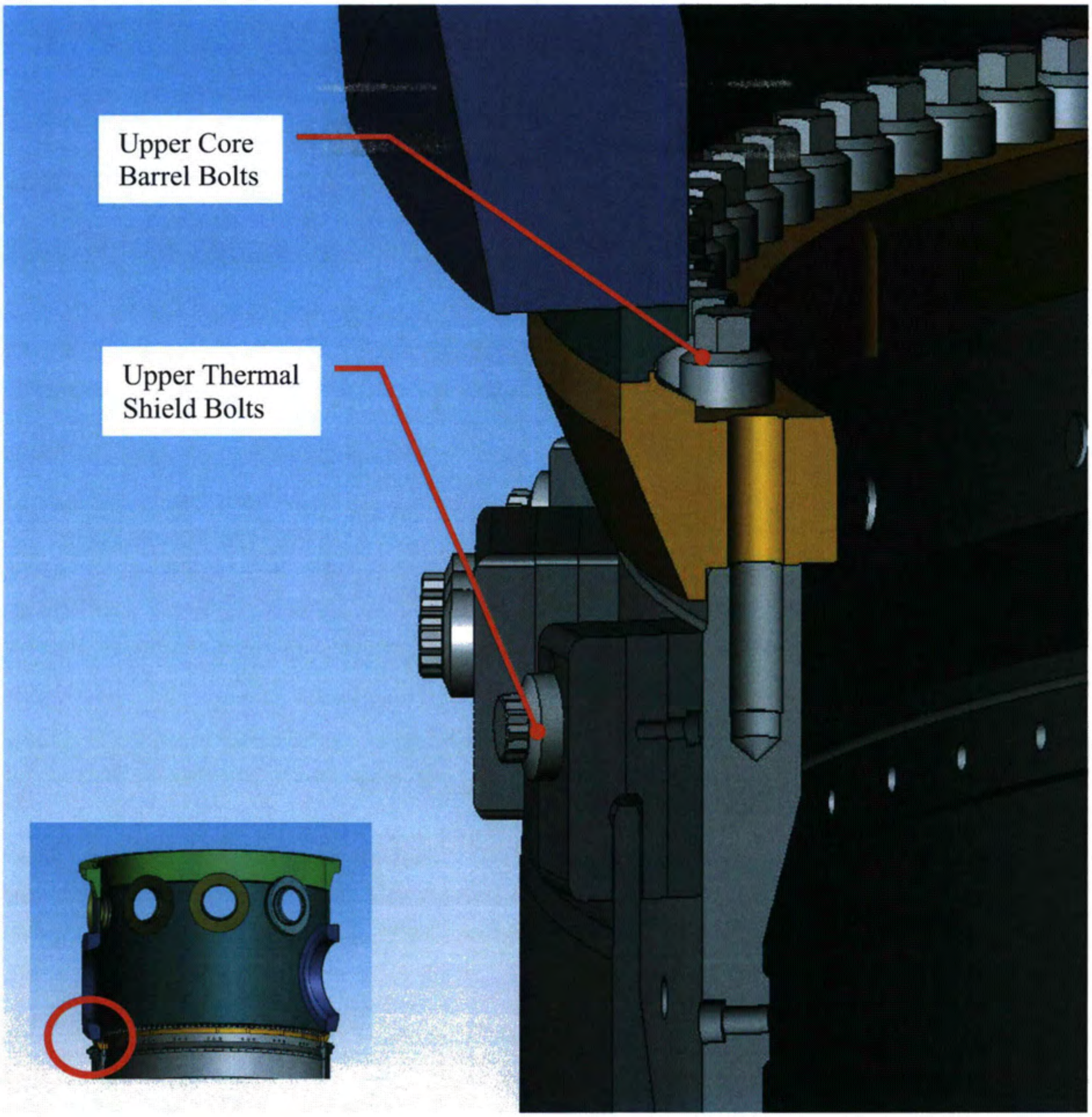


Figure 4-7
Typical upper thermal shield bolts and upper core barrel bolts for B&W-designed PWRs

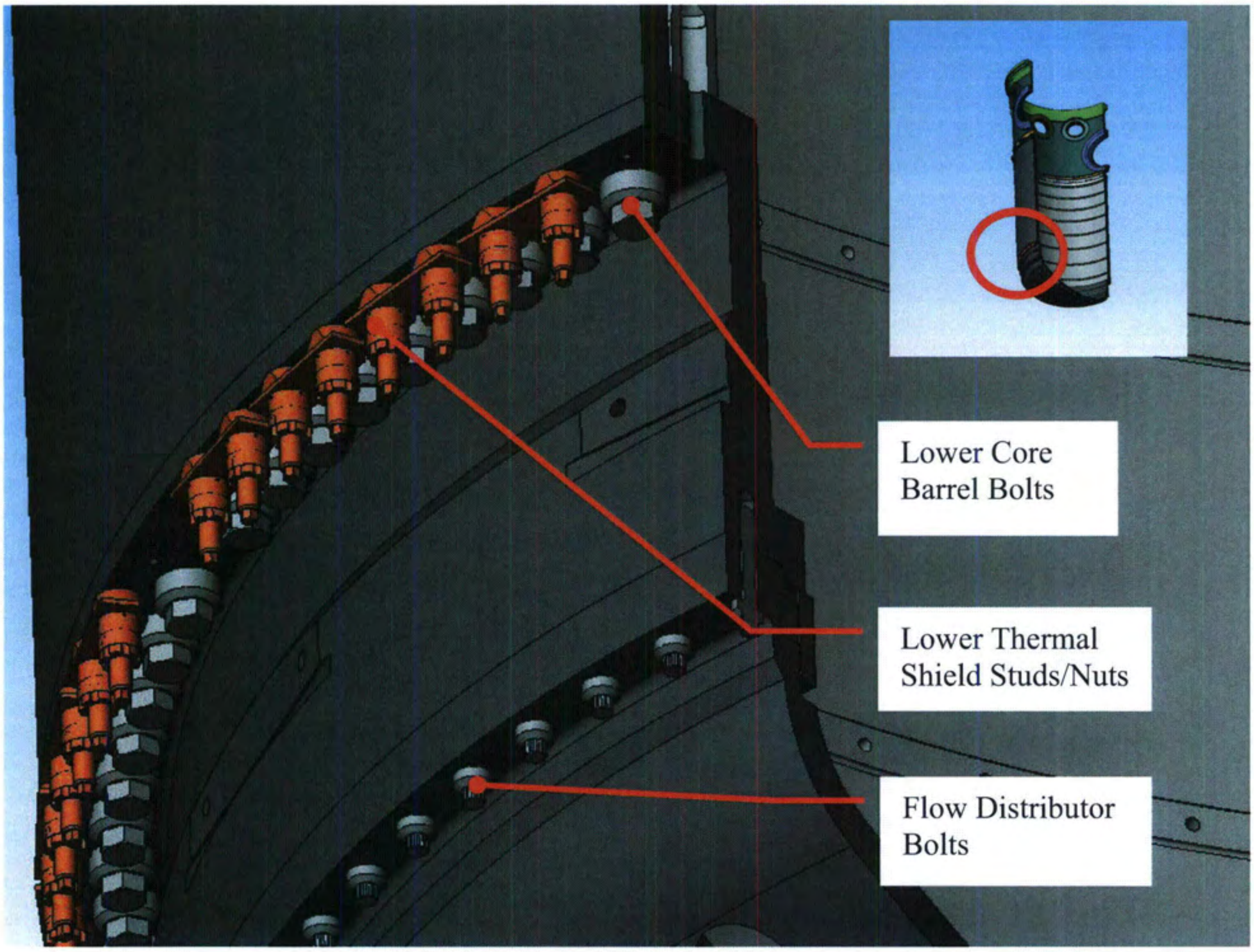


Figure 4-8
Typical lower thermal shield studs/nuts, lower core barrel bolts, and flow distributor bolts for the B&W-designed PWRs

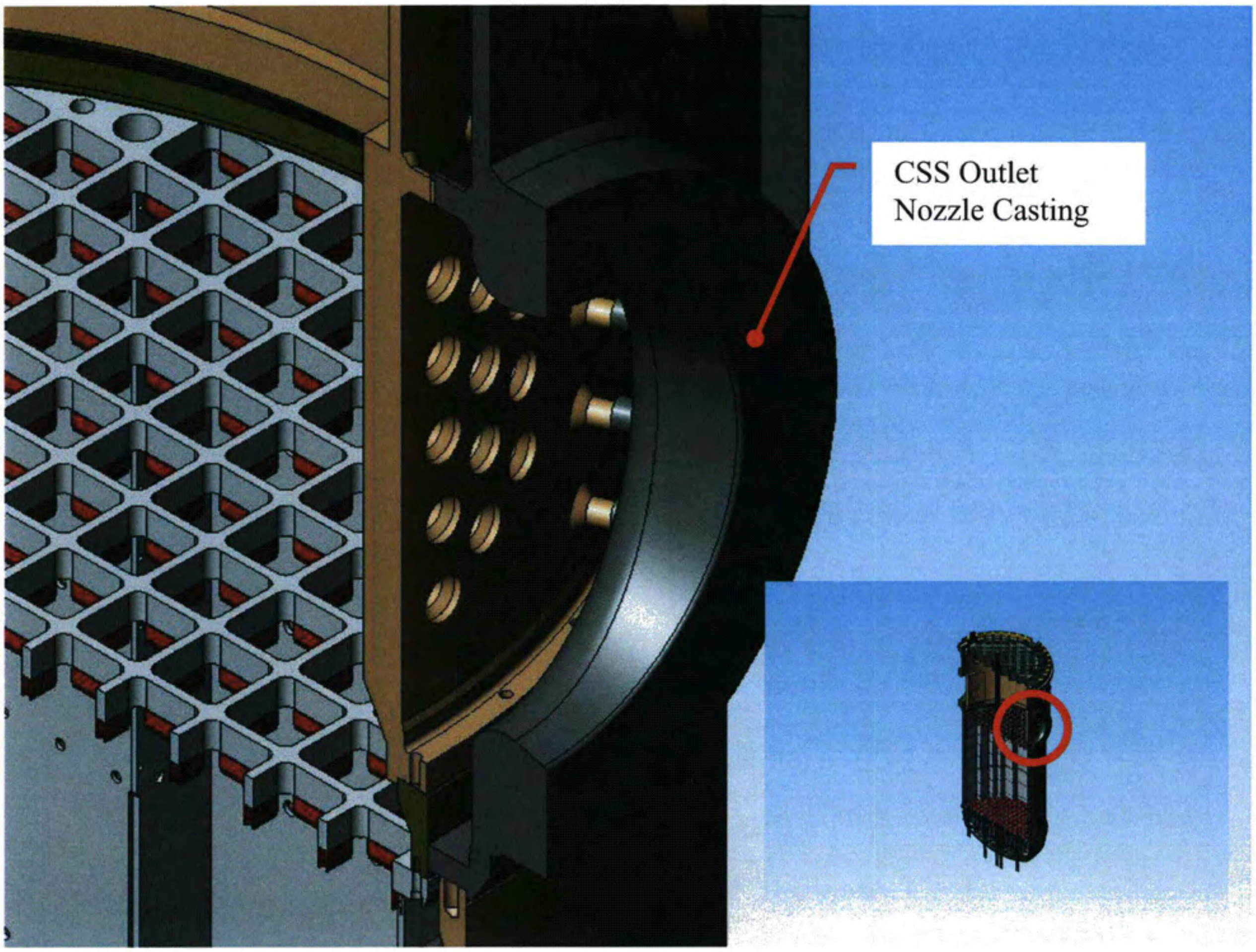


Figure 4-9
Typical core support shield (CSS) outlet nozzle for the B&W-designed PWRs

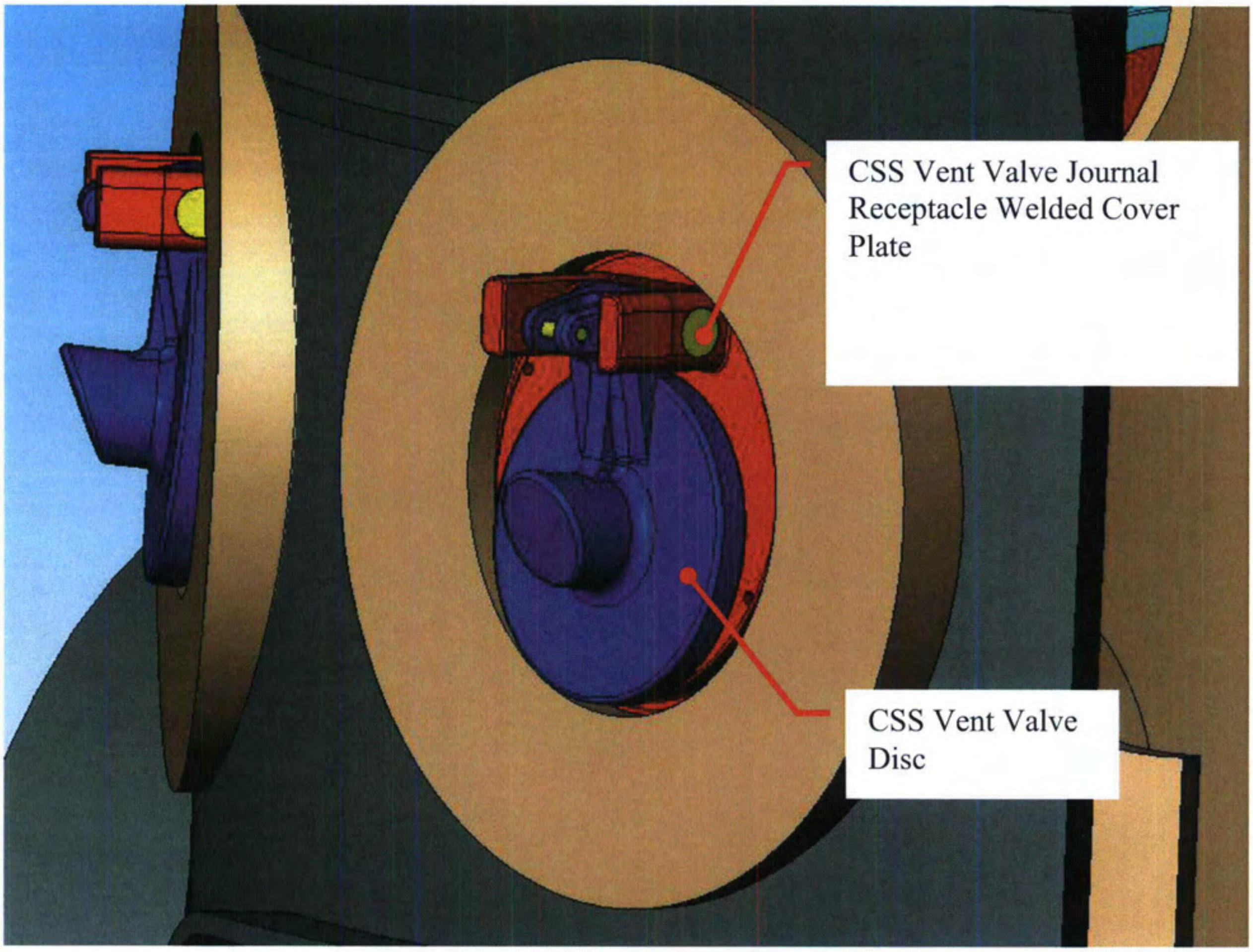


Figure 4-10
Typical core support shield (CSS) vent valve – outside view – for the B&W-designed PWRs

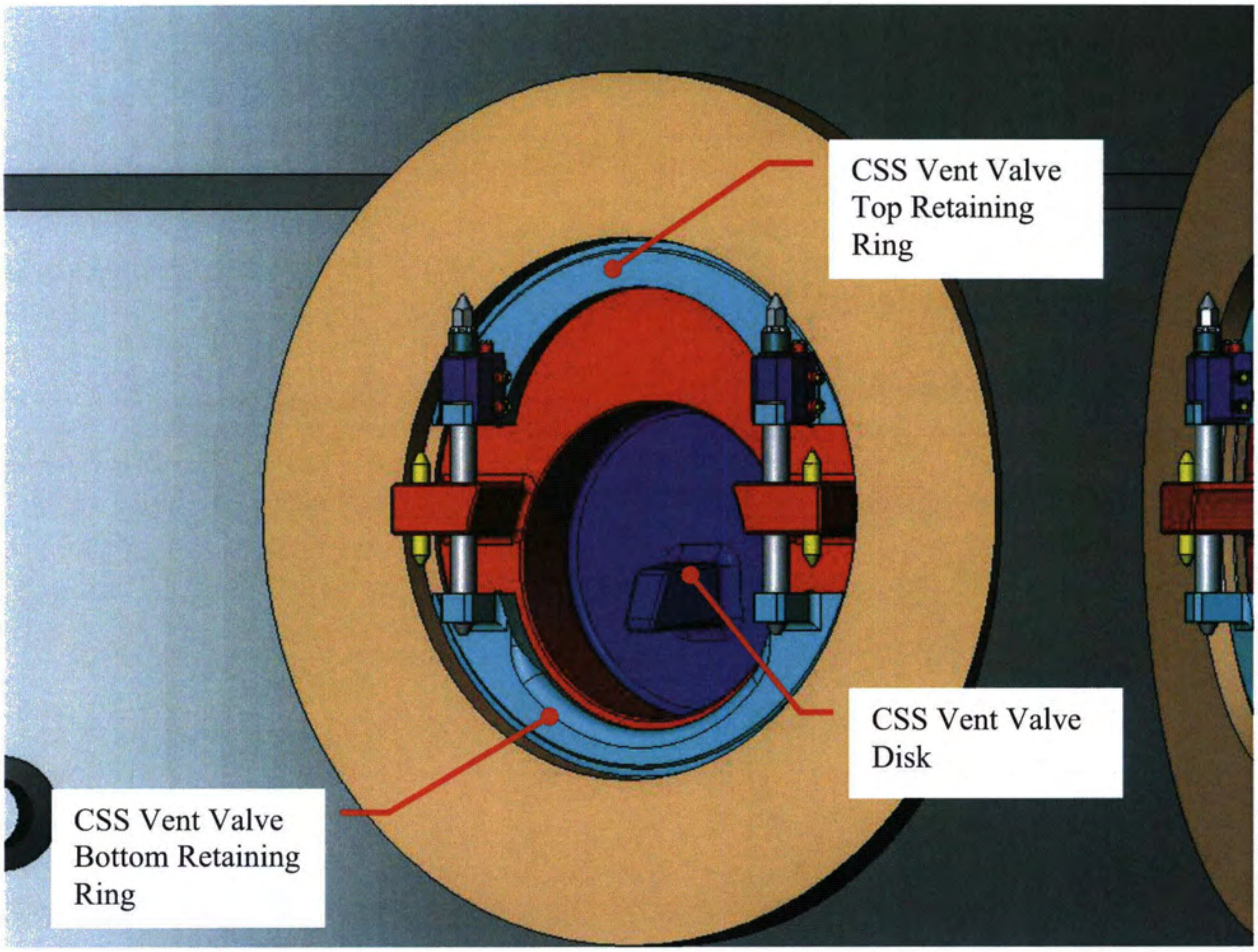


Figure 4-11
Typical core support shield (CSS) vent valve – inside view – for the B&W-designed PWRs

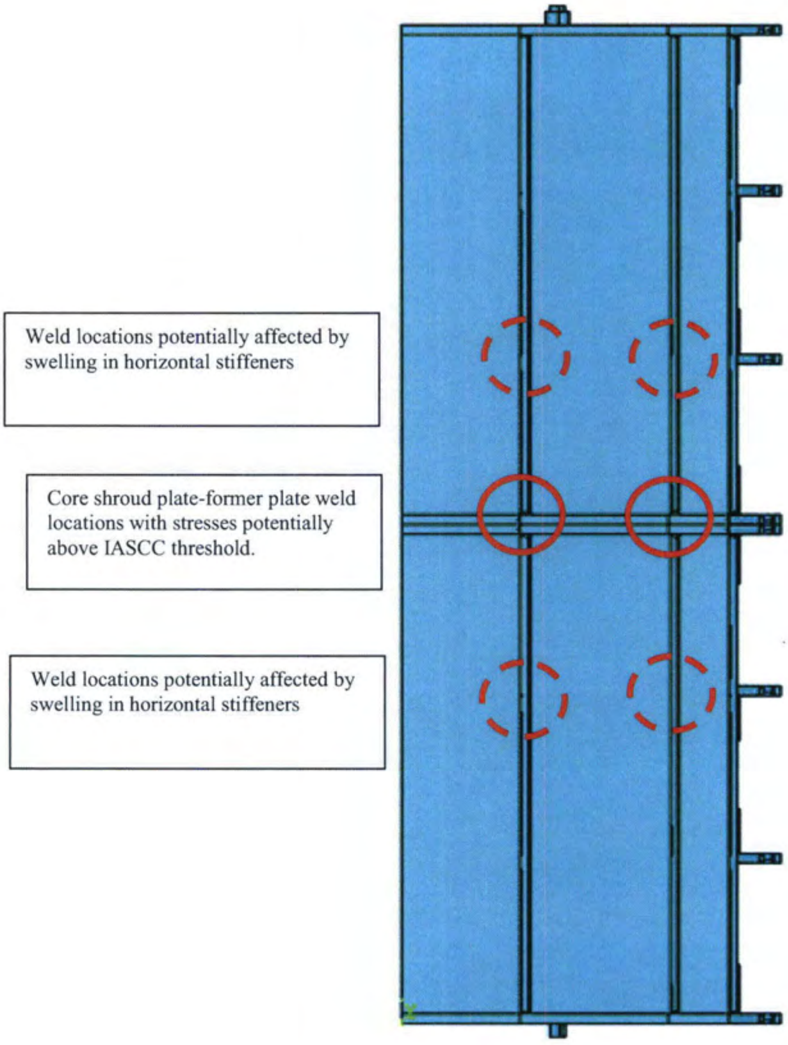


Figure 4-12
Potential crack locations for CE welded core shroud assembled in stacked sections

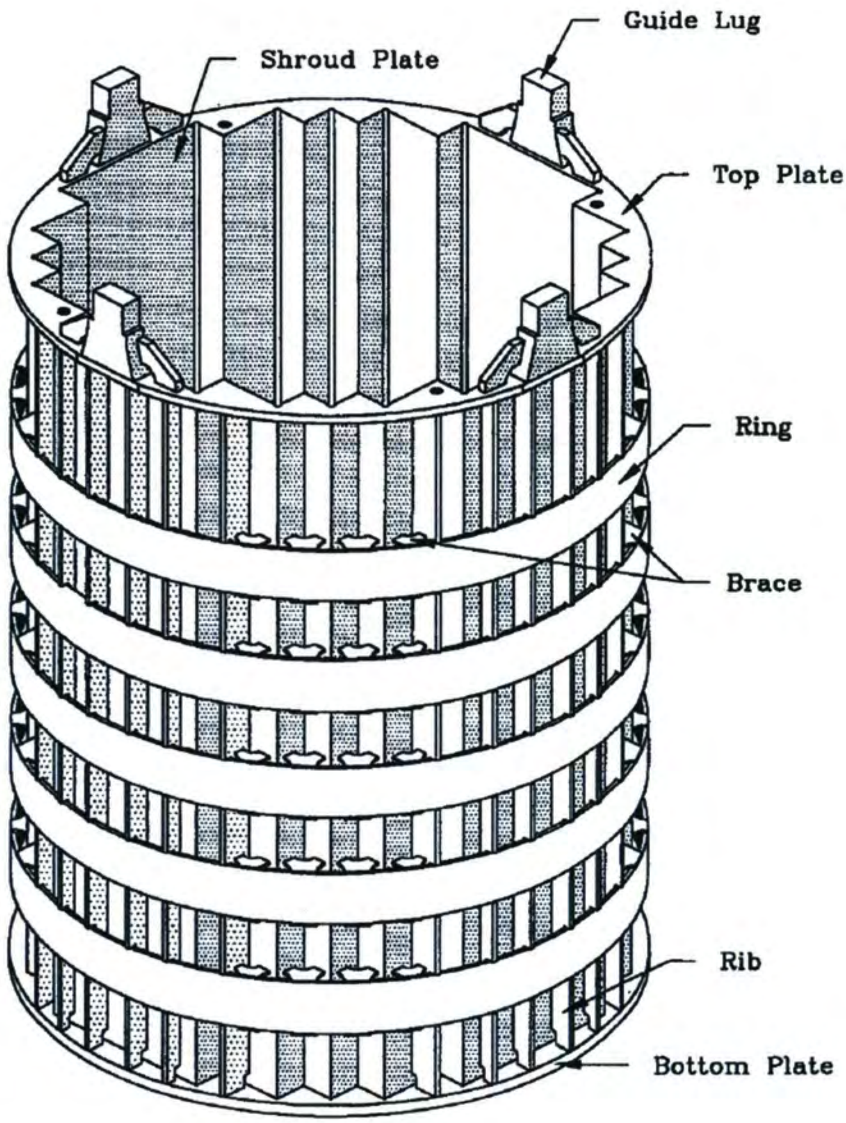


Figure 4-13
CE welded core shroud with full height panels

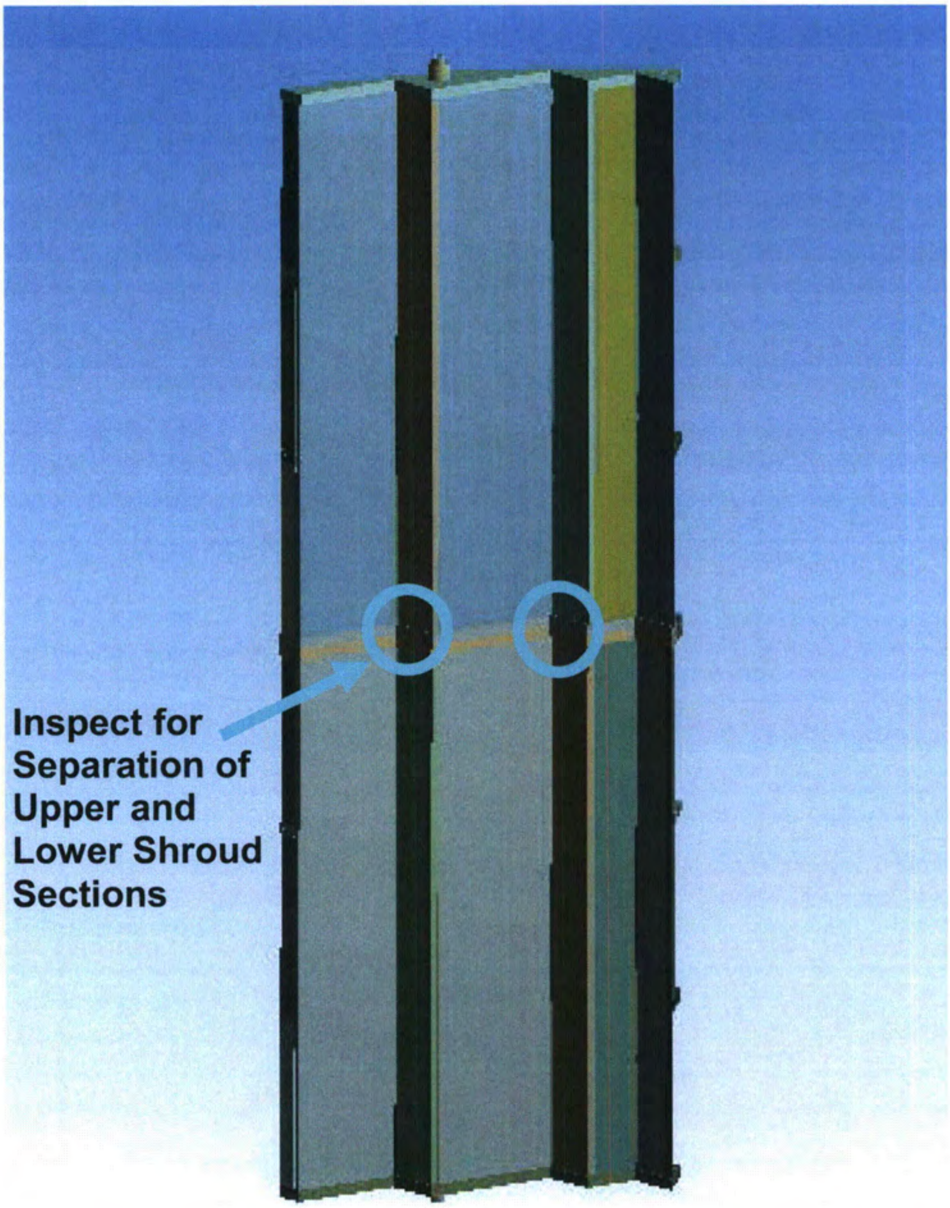


Figure 4-14
Locations of potential separation between core shroud sections caused by swelling induced warping of thick flange plates in CE welded core shroud assembled in stacked sections

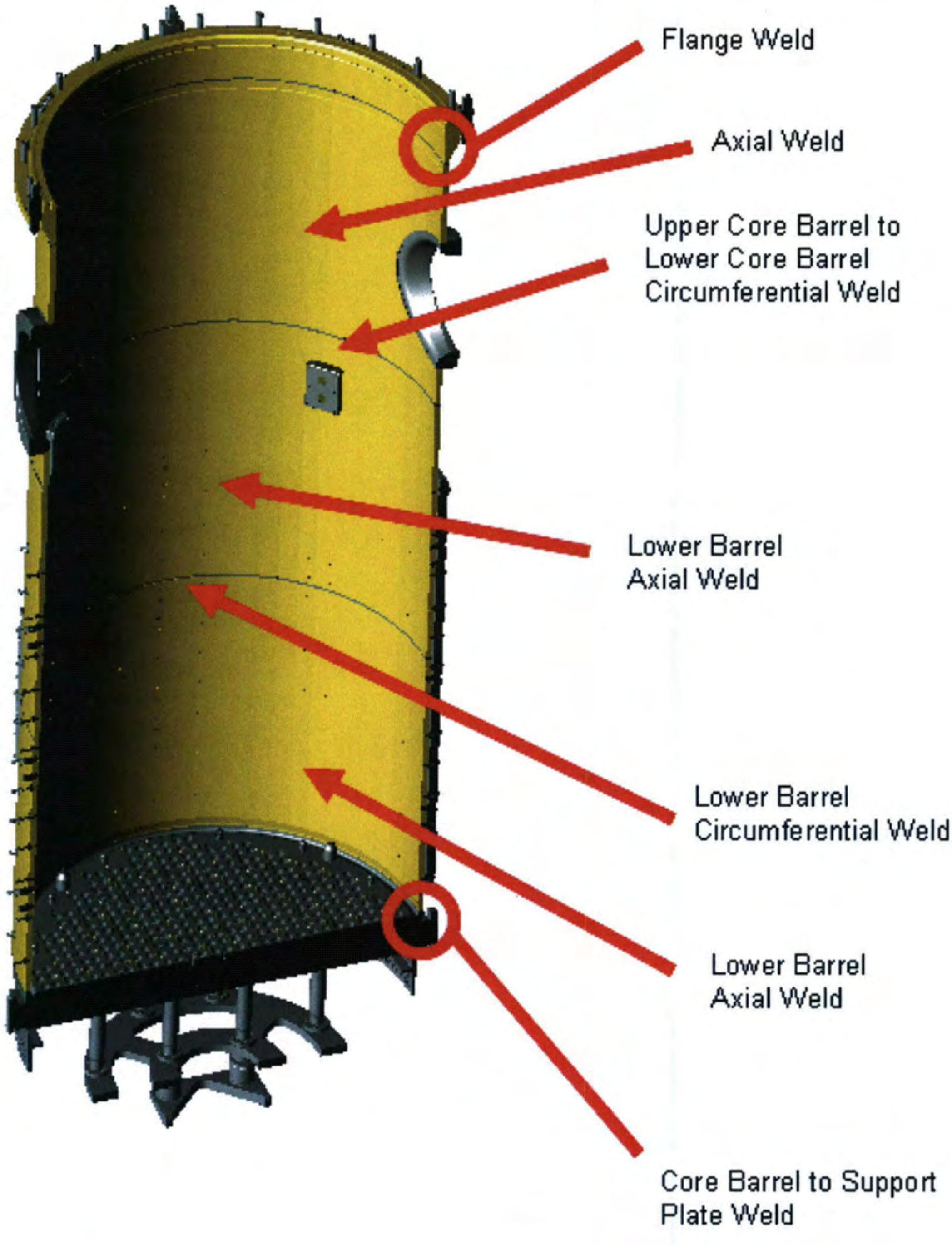
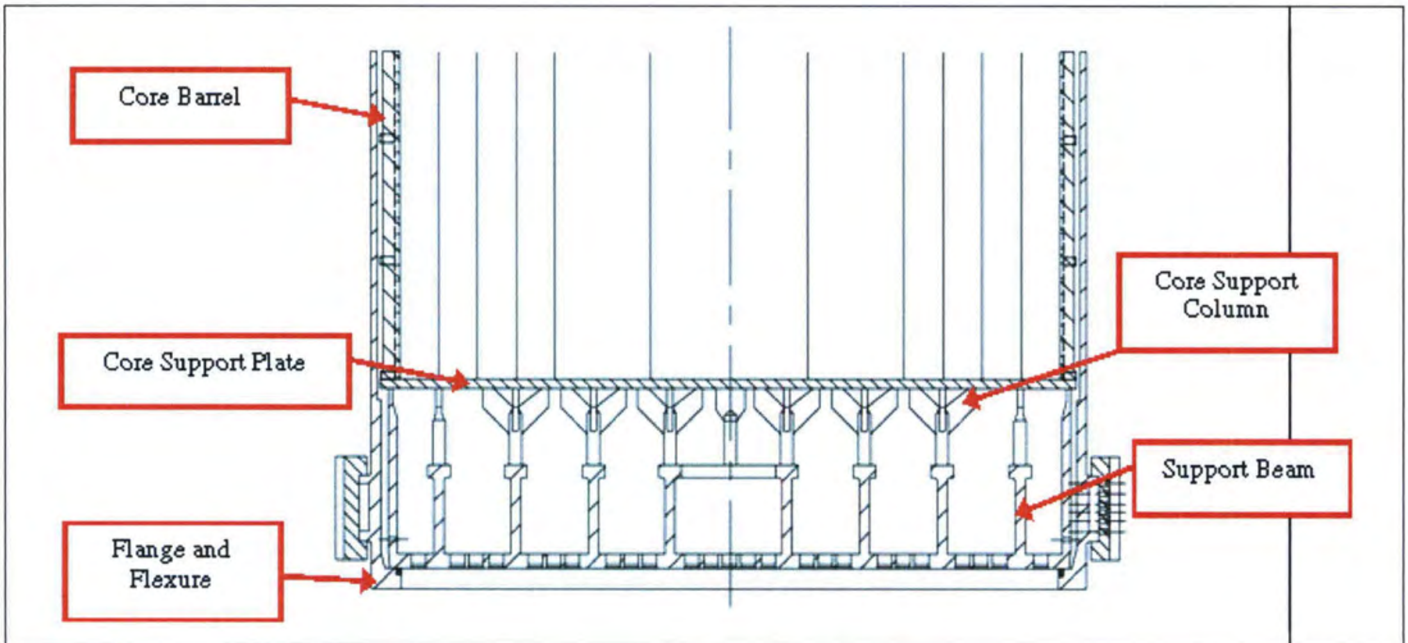


Figure 4-15
Typical CE core support barrel structure



"Winged" Core Support Columns

Core Support Columns without "Winged" Design

Figure 4-16
CE lower support structures for welded core shrouds: separate core barrel and lower support structure assembly with lower flange and core support plate

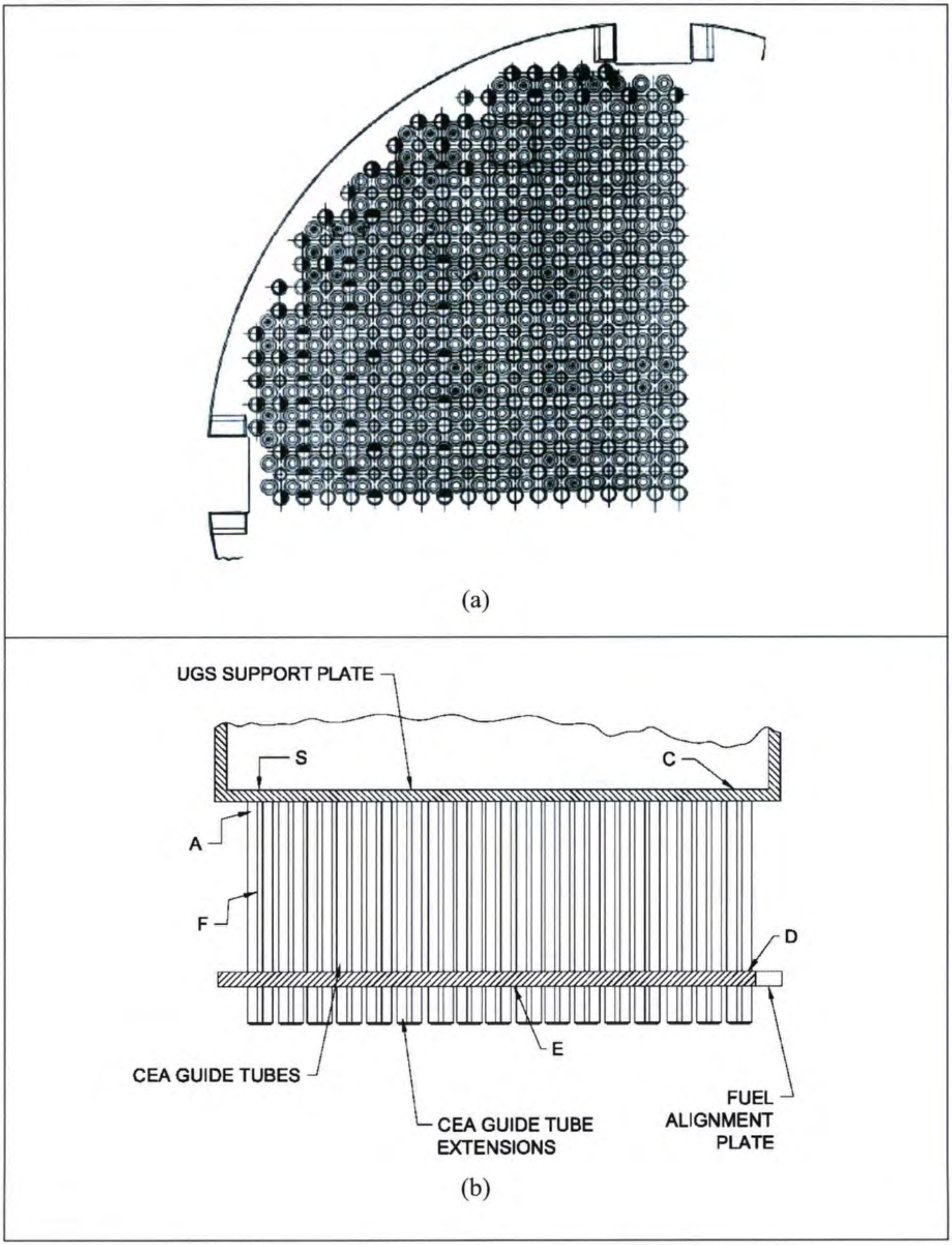


Figure 4-17
(a) Schematic illustration of a portion of the fuel alignment plate, and (b) Radial view schematic illustration of the guide tubes protruding through the plate in upper internals assembly of CE core shrouds with full-height shroud plates

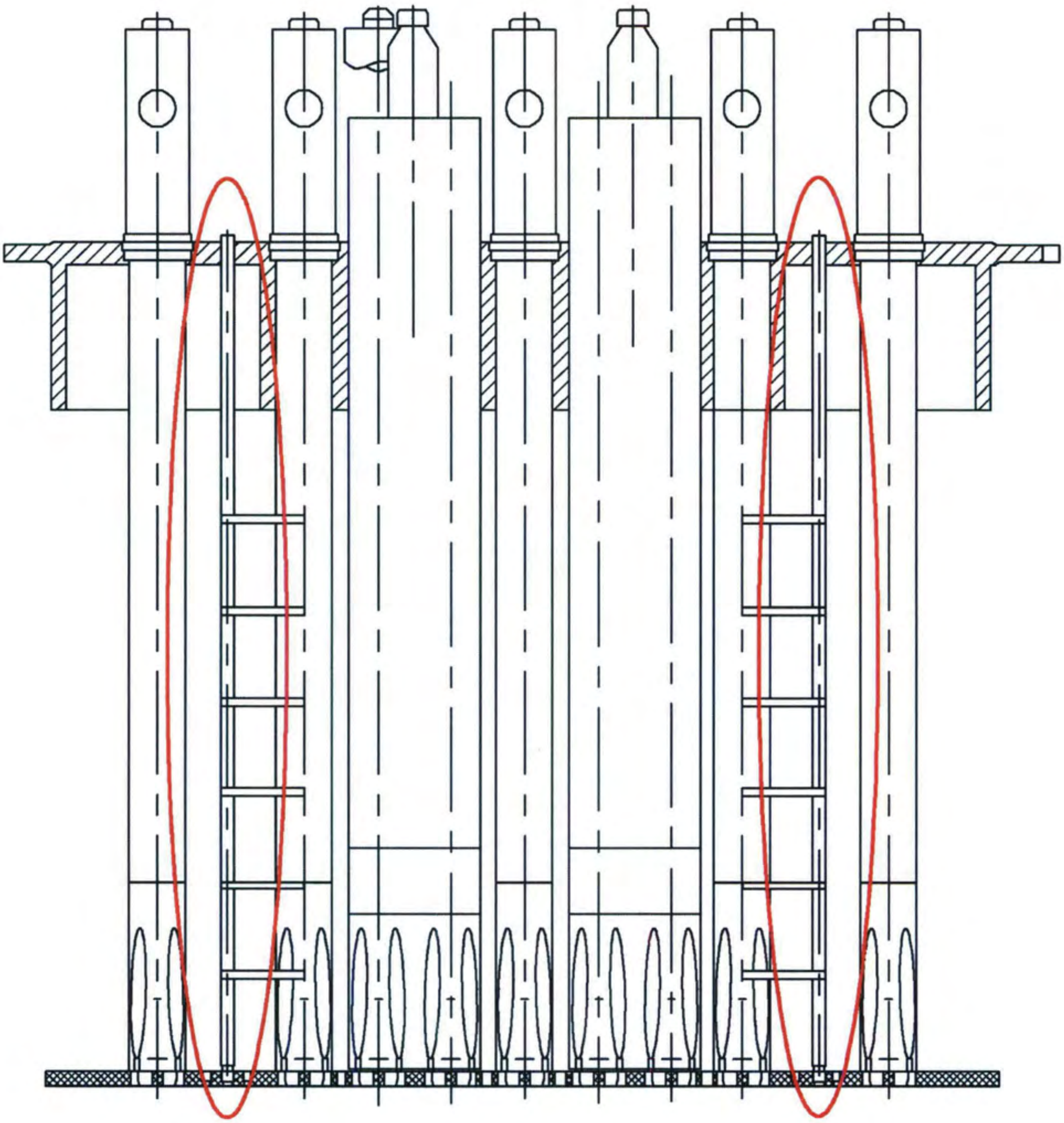
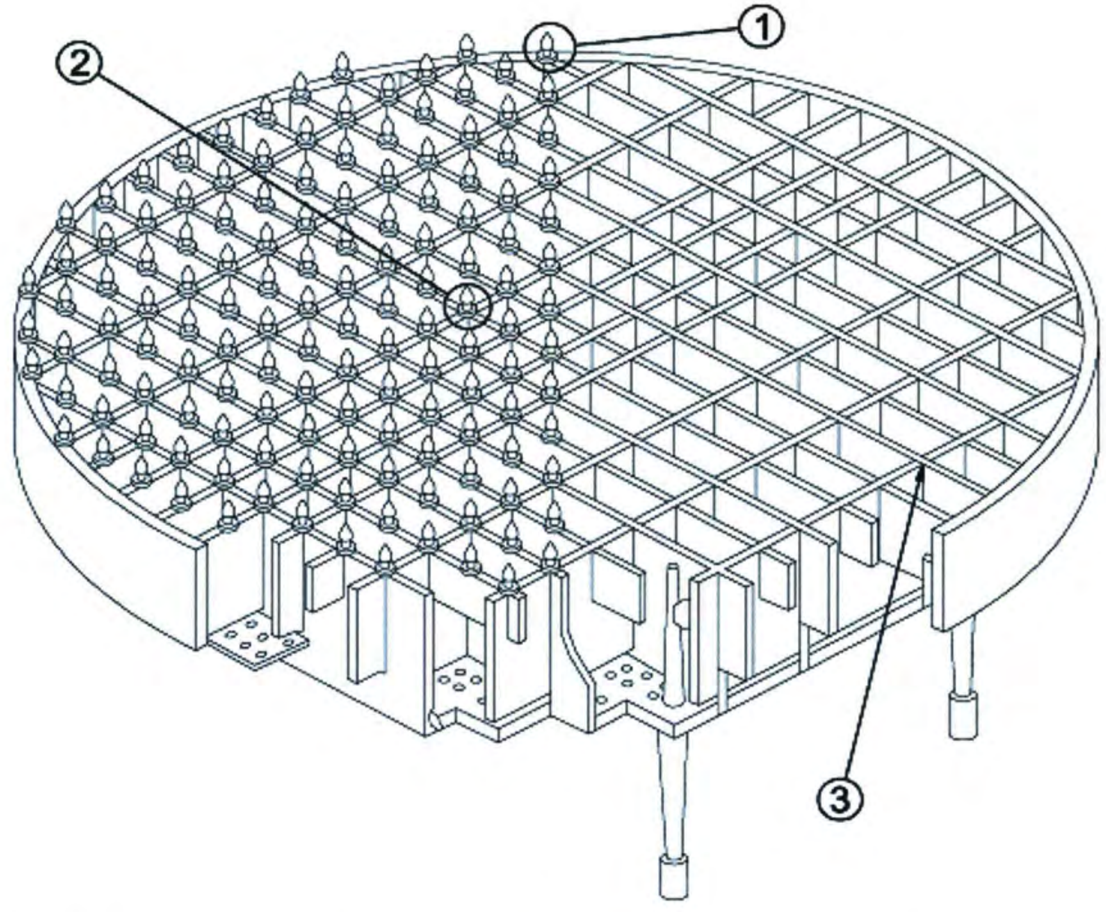


Figure 4-18
CE control element assembly (CEA) shroud instrument tubes (circled in red) are shown, along with the welded supports attaching them to the CEA shroud tube, in this schematic illustration



Illustrates the deep beam grid structure (number 3), as well as the fuel alignment pins (numbers 1 and 2)

Figure 4-19
Isometric view of the lower support structure in the CE core shrouds with full-height shroud plates units. Fuel rests on alignment pins

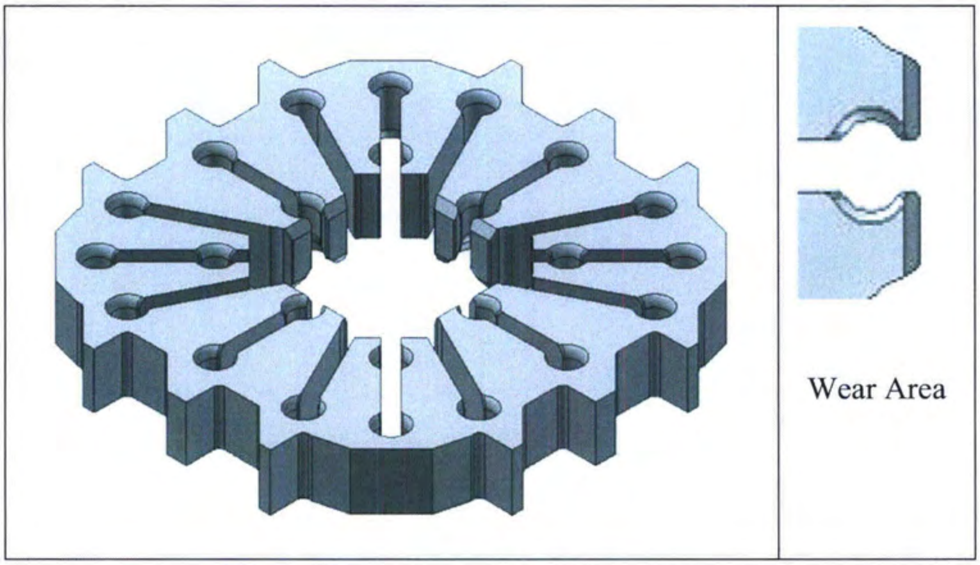


Figure 4-20
Typical Westinghouse control rod guide card (17x17 fuel assembly)

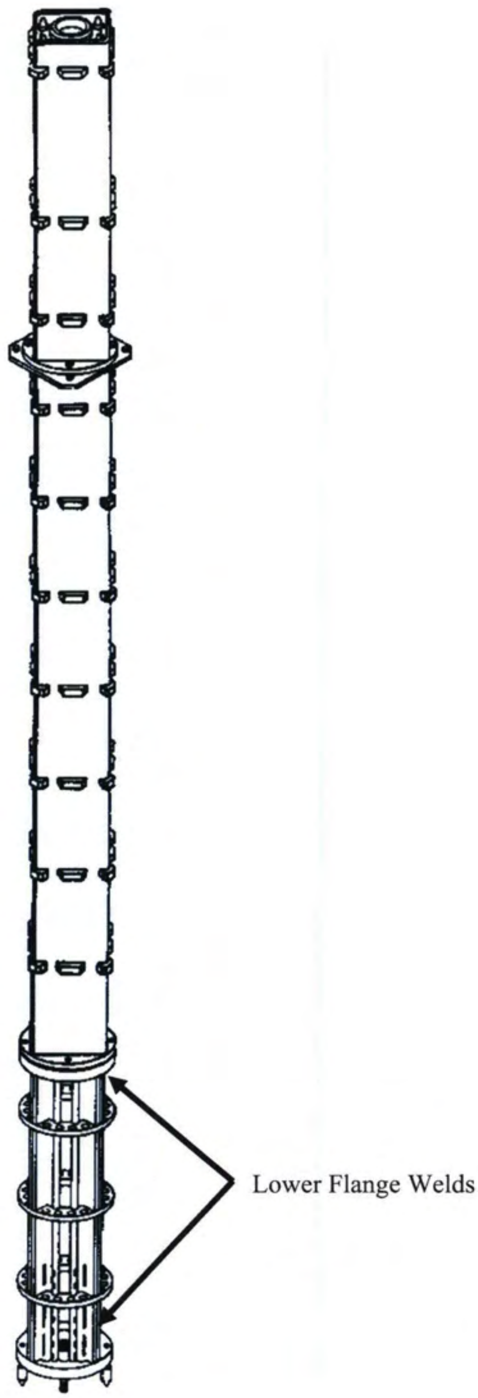


Figure 4-21
Typical Westinghouse control rod guide tube assembly

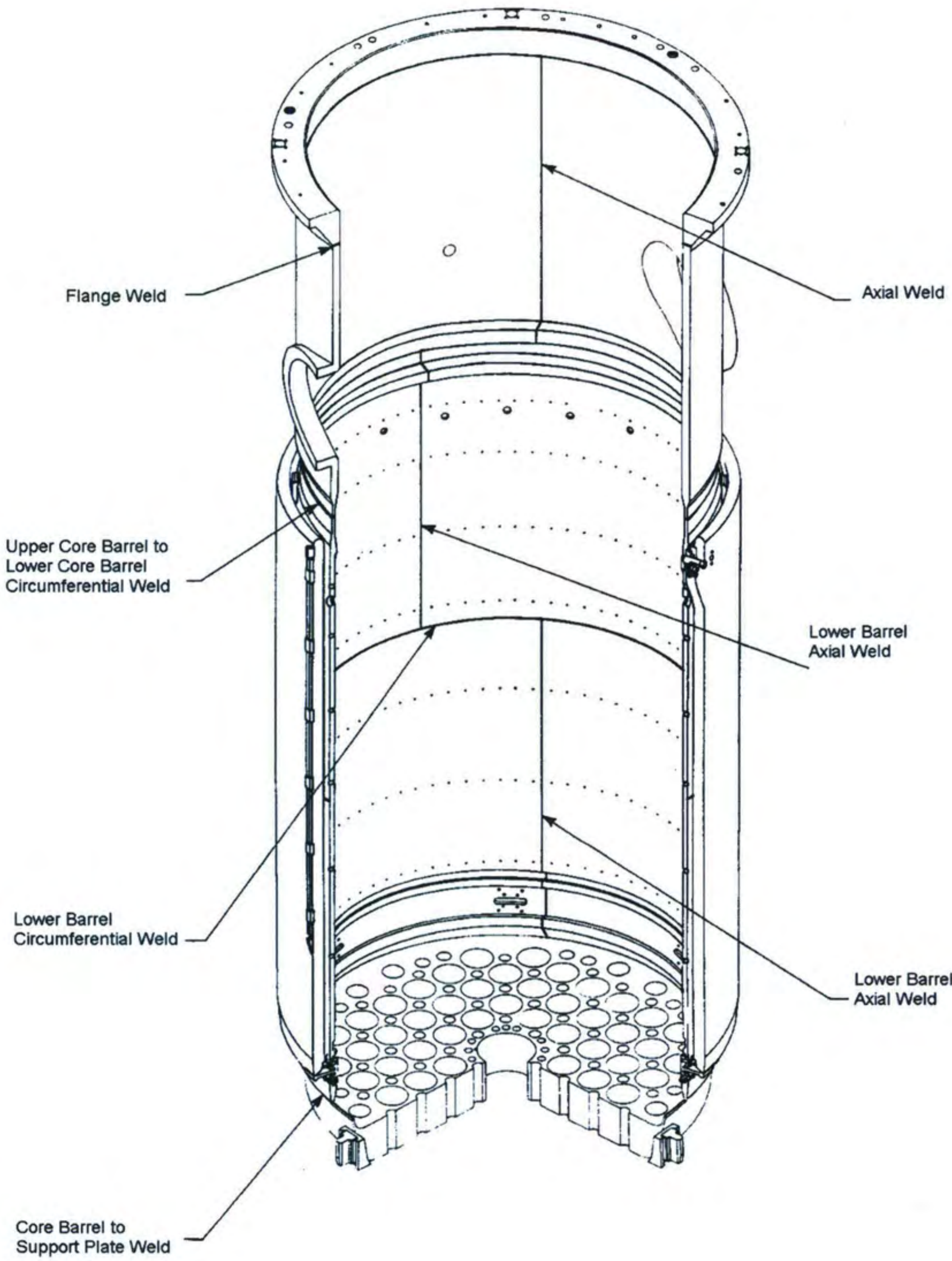


Figure 4-22
Major fabrication welds in typical Westinghouse core barrel

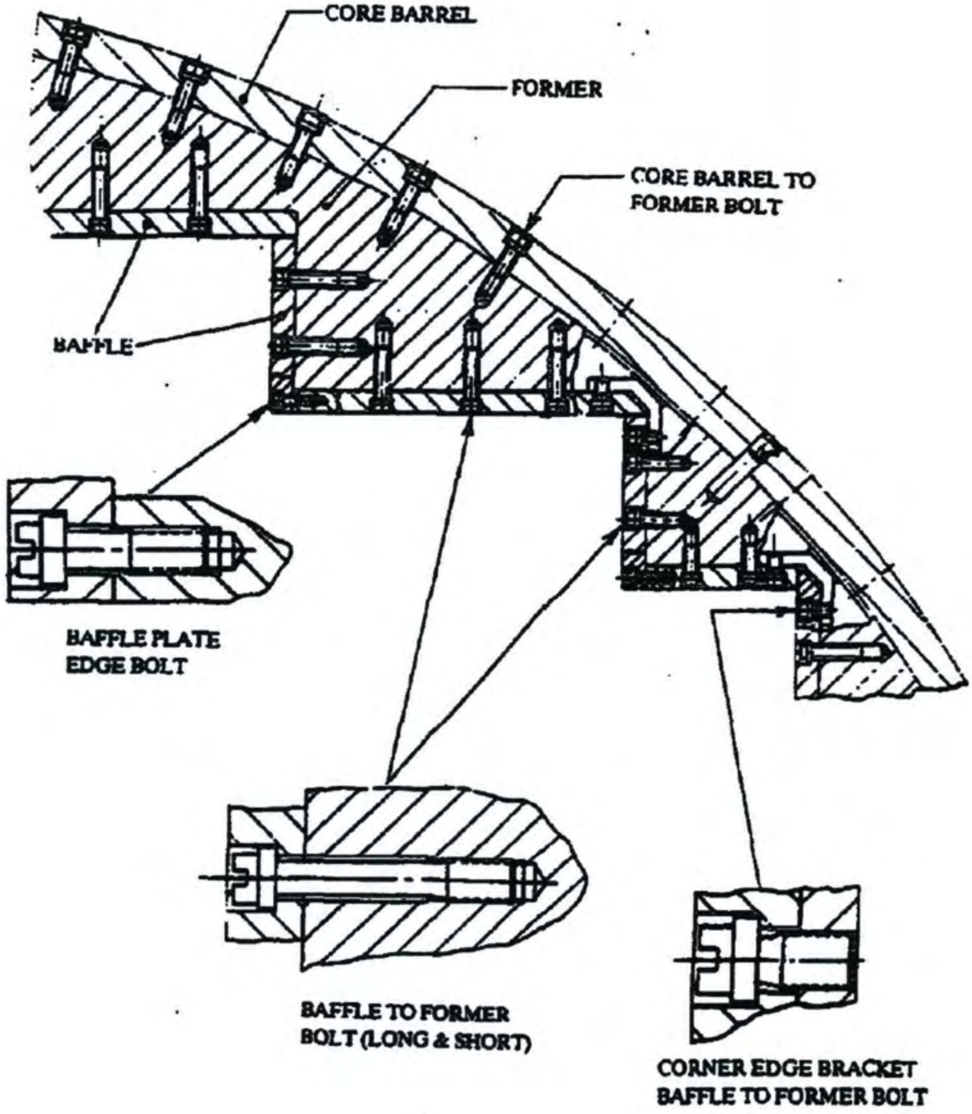


Figure 4-23
Bolt locations in typical Westinghouse baffle-former-barrel structure. In CE plants with bolted shrouds, the core shroud bolts are equivalent to baffle-former bolts and barrel-shroud bolts are equivalent to barrel-former bolts

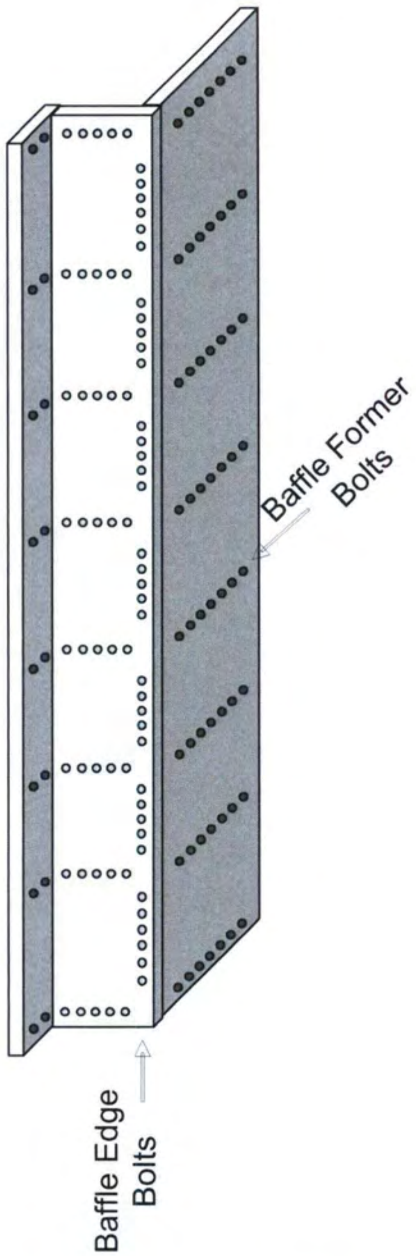


Figure 4-24
Baffle-edge bolt and baffle-former bolt locations at high fluence seams in bolted baffle-former assembly (note: equivalent baffle-former bolt locations in bolted CE shroud designs are core shroud bolts)

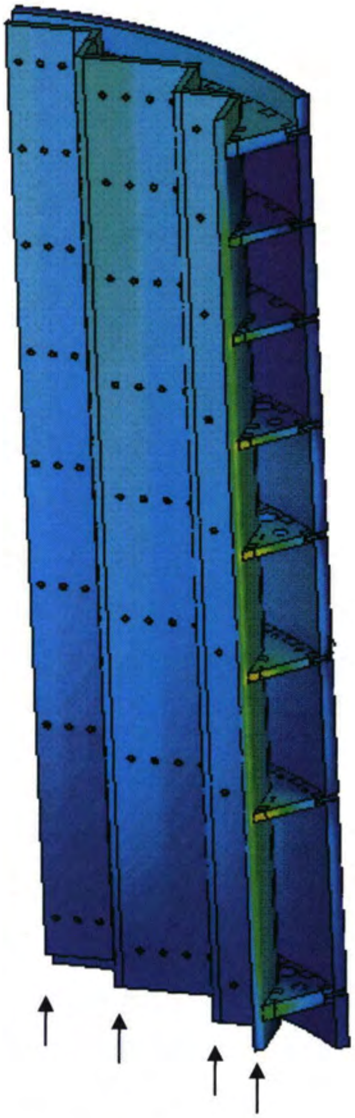


Figure 4-25
High fluence seam locations in Westinghouse baffle-former assembly (full axial length of each of the re-entrant baffle plate corners)

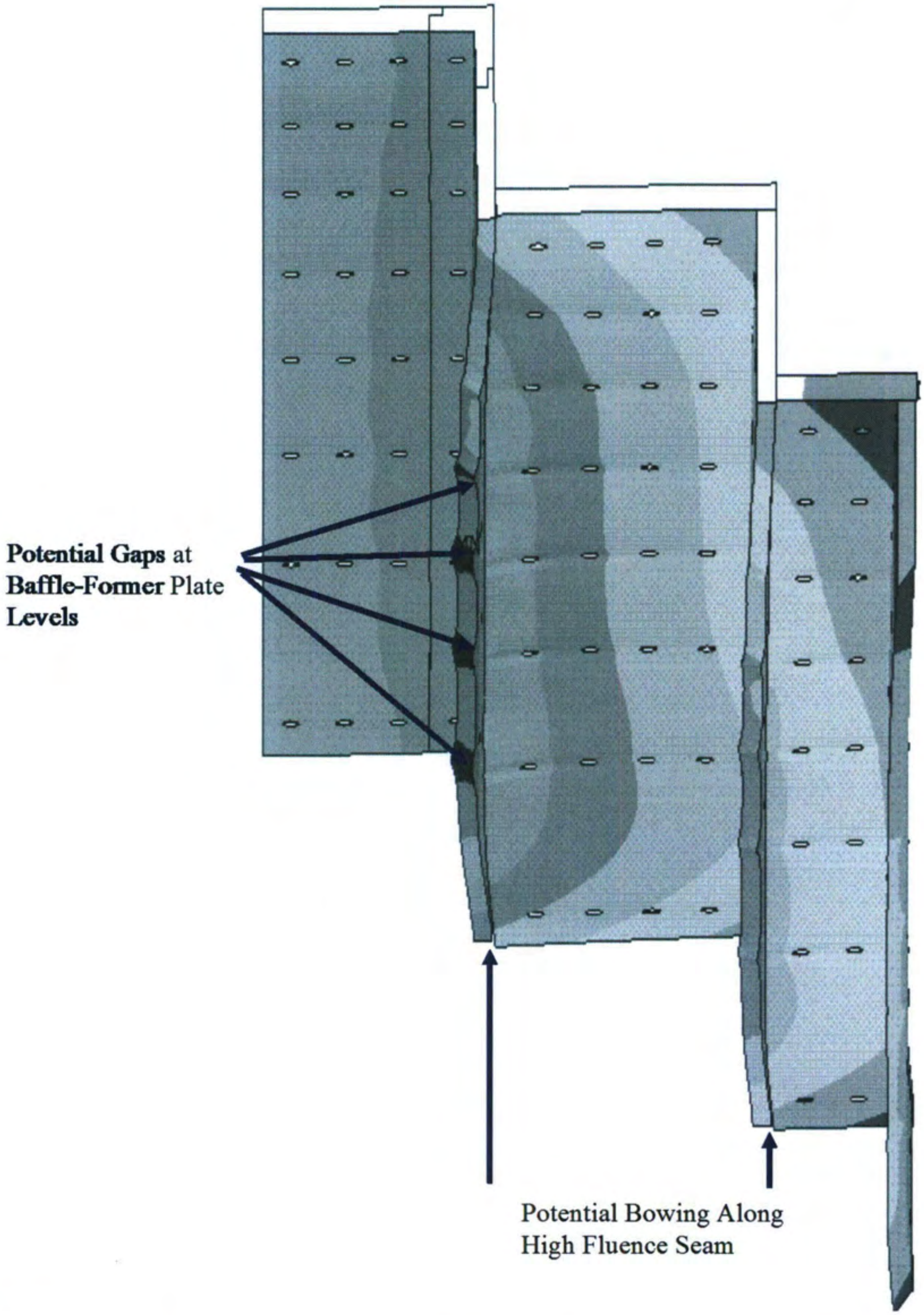


Figure 4-26
Exaggerated view of void swelling induced distortion in Westinghouse baffle-former assembly. This figure also applies to bolted CE shroud designs

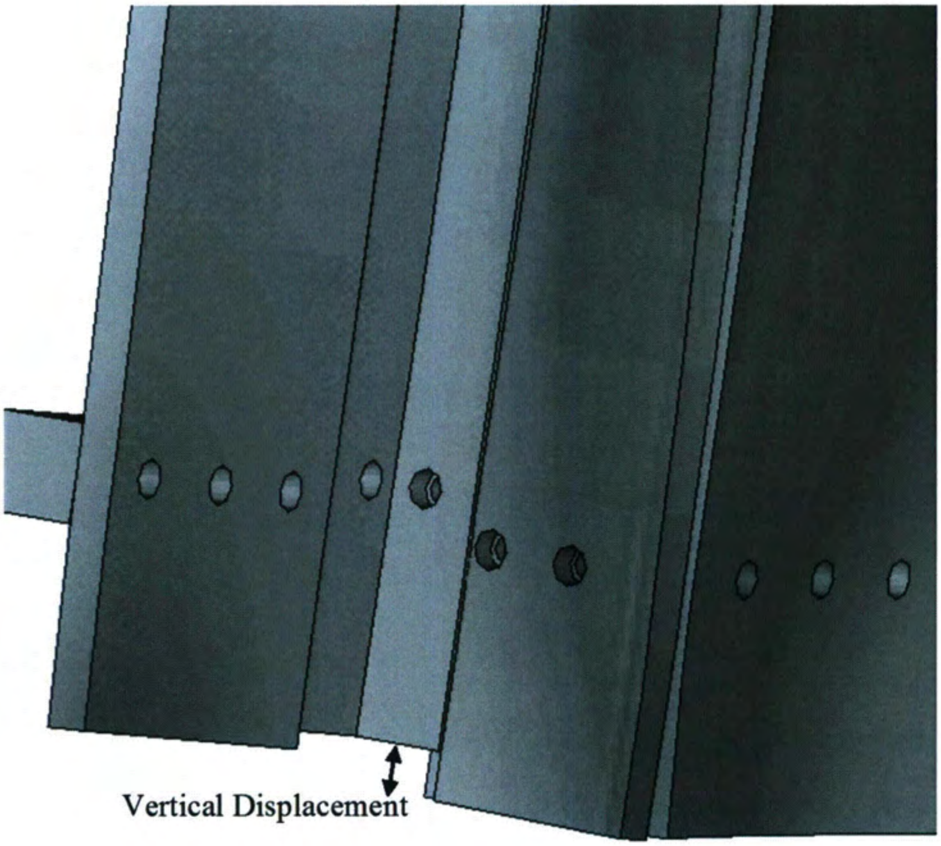


Figure 4-27
Vertical displacement of Westinghouse baffle plates caused by void swelling. This figure also applies to bolted CE shroud designs

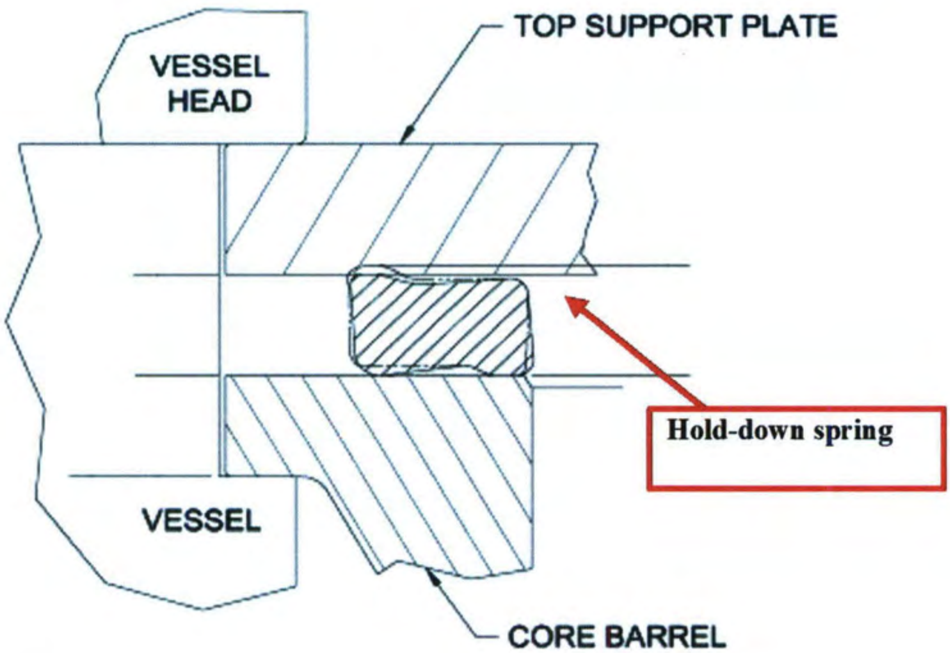


Figure 4-28
Schematic cross-sections of the Westinghouse hold-down springs

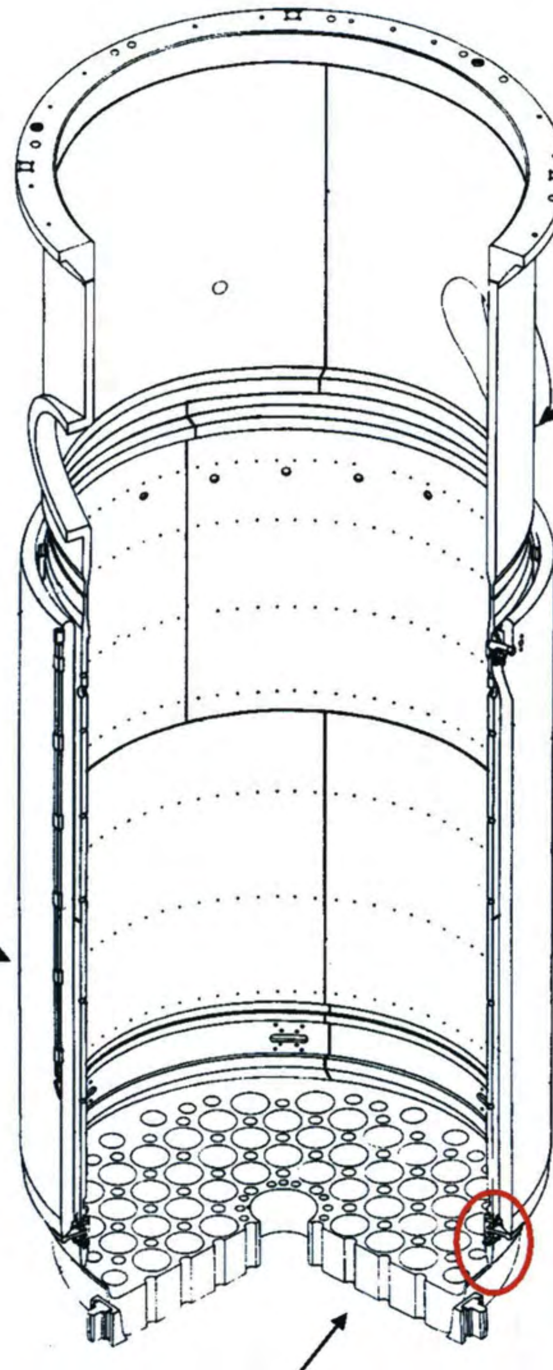


Figure 4-29
Location of Westinghouse thermal shield flexures

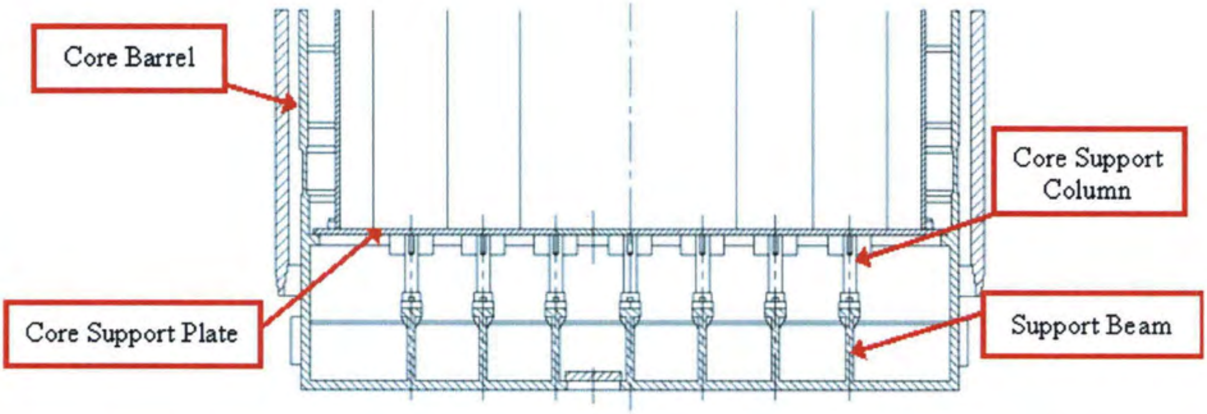
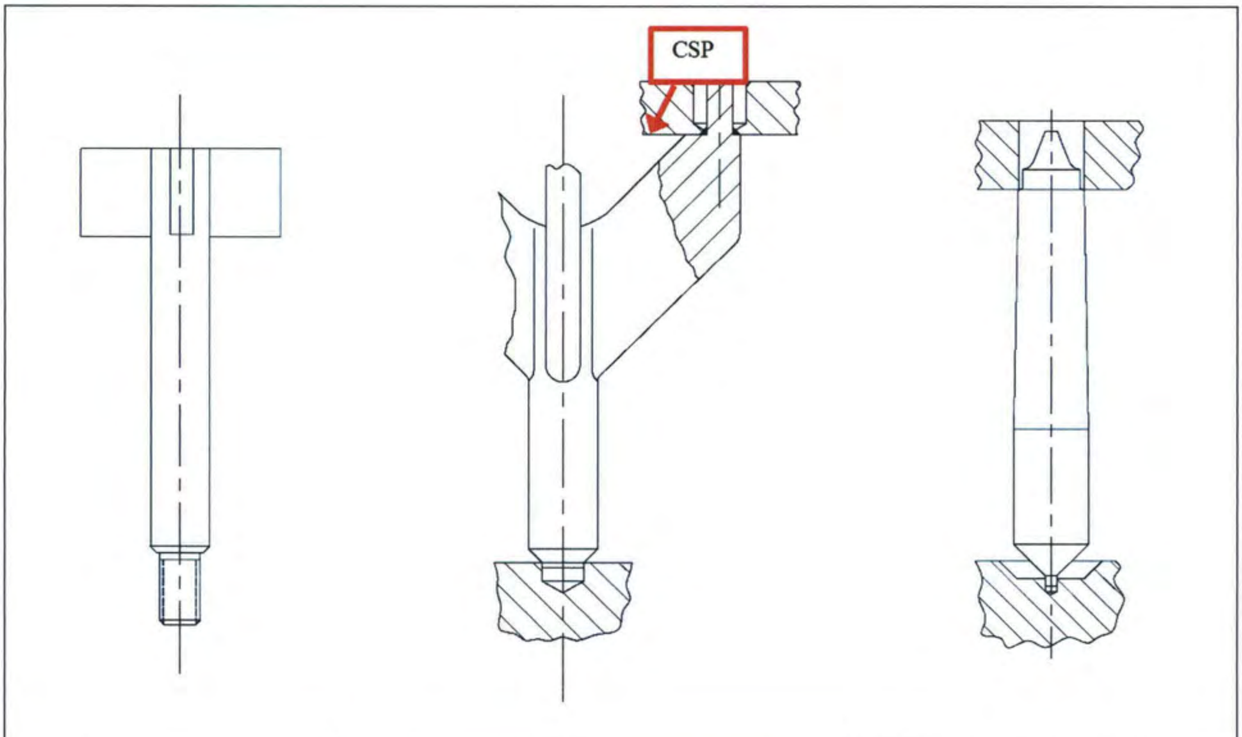


Figure 4-30
CE lower support structure assembly for plants with integrated core barrel and lower support structure with a core support plate (this design does not contain a lower core barrel flange)



a)	b)	c)

a) Early support column design
b) "Winged" support column design and plants with second generation core support assemblies
c) Later support column design used in plants with second generation core support assemblies

Figure 4-31
CE core support columns

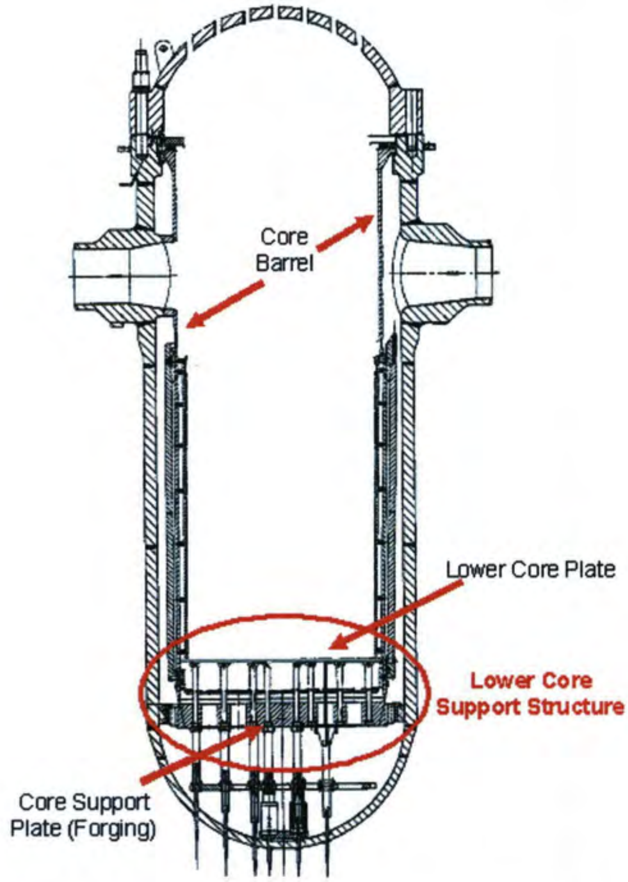


Figure 4-32
Schematic indicating location of Westinghouse lower core support structure. Additional details shown in Figure 4-33

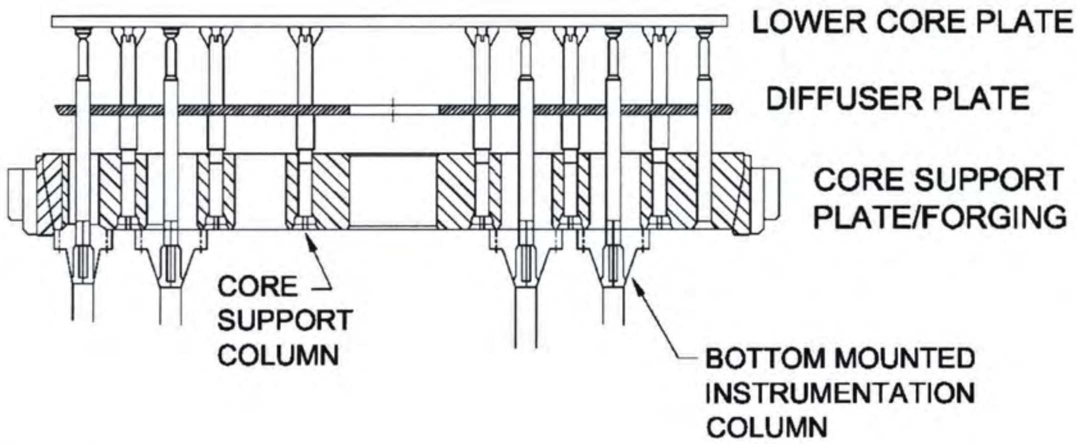


Figure 4-33
Westinghouse lower core support structure and bottom mounted instrumentation columns. Core support column bolts fasten the core support columns to the lower core plate

Figure 4-34
Typical Westinghouse core support column. Core support column bolts fasten the top of the support column to the lower core plate

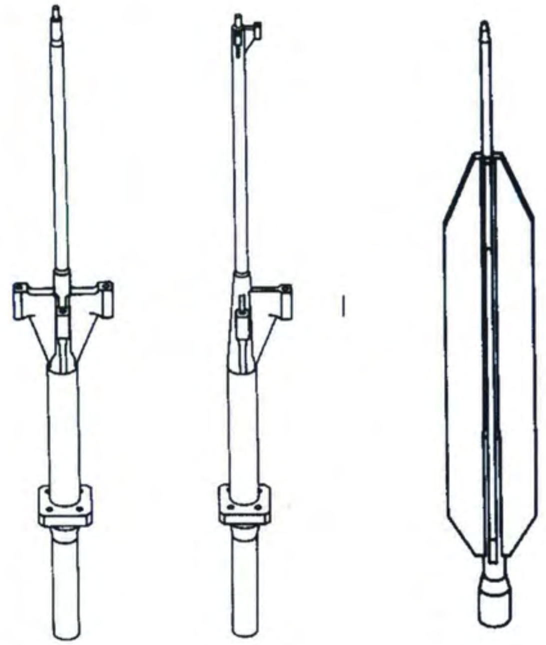


Figure 4-35
Examples of Westinghouse bottom mounted instrumentation column designs

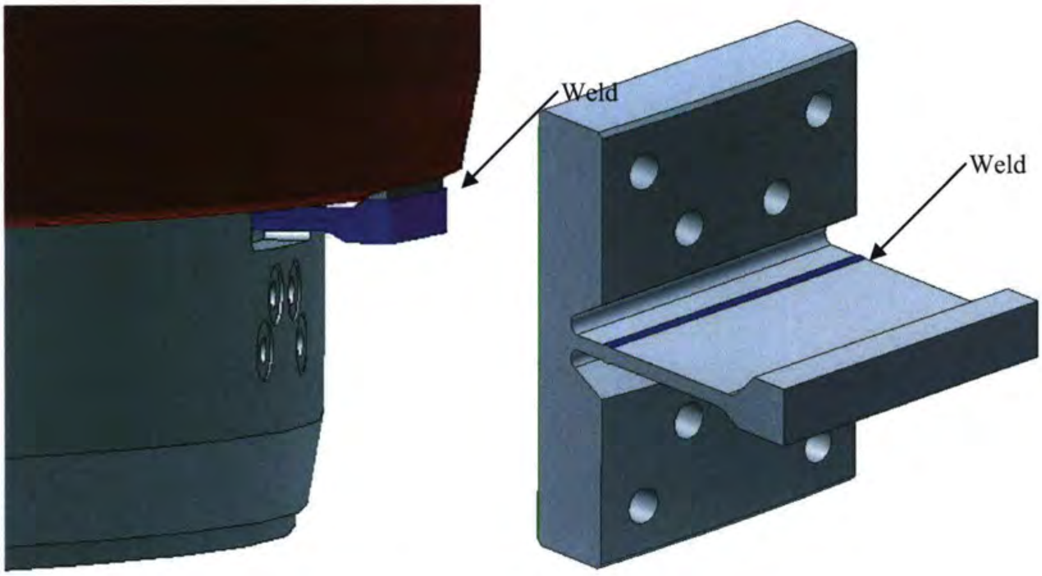


Figure 4-36
Typical Westinghouse thermal shield flexure

4.4 Existing Programs Component Requirements

Existing Programs components are those PWR internals for which current aging management activities required to maintain functionality are being implemented. The continuation of these activities is credited within these guidelines for adequate aging management for specific components.

Included in the Existing Programs are PWR internals that are classified as removable core support structures. ASME Section XI, IWB-2500, Examination Category B-N-3 [2] does not list component specific examination requirements for removable core support structures. Accordingly, factors such as original design, licensing and code of construction variability could result in significant differences in an individual plant's current B-N-3 requirements. These guidelines credit specific components contained within the general B-N-3 classification for maintaining functionality.

These examination requirements, as applied to the components designated in Tables 4-7, 4-8, and 4-9, have been determined to provide sufficient aging management for these components.

Table 4-7
B&W plants Existing Programs components

No existing generic industry programs were considered sufficient for monitoring the aging effects addressed by these guidelines for B&W plants. Therefore, no components for B&W plants were placed into the Existing Programs group.

Table 4-8
CE plants Existing Programs components

Item	Applicability	Effect (Mechanism)	Reference	Examination Method	Examination Coverage
Core Shroud Assembly Guide lugs Guide lug inserts and bolts	All plants	Loss of material (Wear) Aging Management (ISR)	ASME Code Section XI	Visual (VT-3) examination, general condition examination for detection of excessive or asymmetrical wear.	First 10-year ISI after 40 years of operation, and at each subsequent inspection interval. Accessible surfaces at specified frequency.
Lower Support Structure Fuel alignment pins	All plants with core shrouds assembled with full-height shroud plates	Cracking (SCC, IASCC, Fatigue) Aging Management (IE and ISR)	ASME Code Section XI	Visual (VT-3) examination to detect severed fuel alignment pins, missing locking tabs, or excessive wear on the fuel alignment pin nose or flange.	Accessible surfaces at specified frequency.
Lower Support Structure Fuel alignment pins	All plants with core shrouds assembled in two vertical sections	Loss of material (Wear) Aging Management (IE and ISR)	ASME Code Section XI	Visual (VT-3) examination.	Accessible surfaces at specified frequency.
Core Barrel Assembly Upper flange	All plants	Loss of material (Wear)	ASME Code Section XI	Visual (VT-3) examination.	Area of the upper flange potentially susceptible to wear.

Table 4-9
Westinghouse plants Existing Programs components

Item	Applicability	Effect (Mechanism)	Reference	Examination Method	Examination Coverage
Core Barrel Assembly Core barrel flange	All plants	Loss of material (Wear)	ASME Code Section XI	Visual (VT-3) examination to determine general condition for excessive wear.	All accessible surfaces at specified frequency.
Upper Internals Assembly Upper support ring or skirt	All plants	Cracking (SCC, Fatigue)	ASME Code Section XI	Visual (VT-3) examination.	All accessible surfaces at specified frequency.
Lower Internals Assembly Lower core plate XL lower core plate (Note 1)	All plants	Cracking (IASCC, Fatigue) Aging Management (IE)	ASME Code Section XI	Visual (VT-3) examination of the lower core plates to detect evidence of distortion and/or loss of bolt integrity.	All accessible surfaces at specified frequency.
Lower Internals Assembly Lower core plate XL lower core plate (Note 1)	All plants	Loss of material (Wear)	ASME Code Section XI	Visual (VT-3) examination.	All accessible surfaces at specified frequency.
Bottom Mounted Instrumentation System Flux thimble tubes	All plants	Loss of material (Wear)	NUREG-1801 Rev. 1	Surface (ET) examination.	Eddy current surface examination as defined in plant response to IEB 88-09.
Alignment and Interfacing Components Clevis insert bolts	All plants	Loss of material (Wear) (Note 2)	ASME Code Section XI	Visual (VT-3) examination.	All accessible surfaces at specified frequency.
Alignment and Interfacing Components Upper core plate alignment pins	All plants	Loss of material (Wear)	ASME Code Section XI	Visual (VT-3) examination.	All accessible surfaces at specified frequency.

Notes to Table 4-9:

1. XL = "Extra Long" referring to Westinghouse plants with 14-foot cores.
2. Bolt was screened in because of stress relaxation and associated cracking; however, wear of the clevis/insert is the issue.

Also included in Existing Programs are those components for which existing guidance has been issued (e.g., from the nuclear steam supply system (NSSS) vendors or Owners Groups) to address degradation that manifested itself during the current operational life of the PWR fleet. The continued implementation of this guidance has been determined to adequately manage the aging effects for these components.

4.4.1 B&W Components

Table 4-7 describes the PWR internals in the Existing Programs for B&W plants.

No existing generic industry programs contain the specificity considered sufficient for monitoring the aging effects addressed by these guidelines for B&W plants. Therefore, no components for B&W plants were placed into the Existing Programs group.

4.4.2 CE Components

Table 4-8 describes the PWR internals in the Existing Programs for CE plants.

The following is a list of the CE Existing Programs Components.

- ***ASME Section XI***

  Existing:

  - Guide lugs and guide lug inserts and bolts (applicable to all plants)
  - Fuel alignment pins (applicable to all plants with core shrouds assembled with full-height shroud plates and all plants with core shrouds assembled in two vertical sections)
  - Upper flange (applicable to all plants)

These component items may be considered core support structures listings that are typically examined during the 10-year inservice inspection per ASME Code Section XI Table IWB-2510, B-N-3 [2]. For these component items, the requirements of B-N-3 (visual VT-3) are considered sufficient to monitor for the aging effects addressed by these guidelines.

- ***Plant-specific***

The guidance for ICI thimble tubes and thermal shield positioning pins is limited to plant specific recommendations and thus have no generic reference, nor are they included in Table 4-8. The owner should review their specific design, upgrade status, and plant commitments for CE ICI thimble tubes.

4.4.3 Westinghouse Components

Table 4-9 describes the PWR internals in the Existing Programs for Westinghouse plants.

The following is a list of the Westinghouse Existing Programs Components.

- ***ASME Section XI***

  Existing:

  - Core barrel flange (applicable to all plants)
  - Upper support ring or skirt (applicable to all plants)
  - Lower core plate and XL lower core plate (applicable to all plants)
  - Clevis insert bolts (applicable to all plants)
  - Upper core plate alignment pins (applicable to all plants)

These component items are considered core support structures that are typically examined during the 10-year inservice inspection per ASME Code Section XI Table IWB-2510, B-N-3 [2]. For these component items, the requirements of B-N-3 (visual VT-3) are considered sufficient to monitor for the aging effects addressed by these guidelines.

- ***Plant-specific***

The guidance for flux thimble tubes is included in Table 4-9 and is based on owner commitments.

The guidance for guide tube support pins (split pins) is limited to plant specific recommendations and thus have no generic reference. Subsequent performance monitoring should follow the supplier recommendations. They thus are not included in Table 4-9. The owner should review their specific design, upgrade status, and asset management plans for Westinghouse guide tube support pins (split pins).

4.5 No Additional Measures Components

It has been determined that no additional aging management is necessary for components in this group. In no case does this determination relieve utilities of the ASME Code Section XI [2] IWB Examination Category B-N-3 inservice inspection requirements for components from this group classified as core support structures unless specific relief is granted as allowed by 10CFR50.55a [4].

5
EXAMINATION ACCEPTANCE CRITERIA AND EXPANSION CRITERIA

The purpose of this section is to provide both examination acceptance criteria for conditions detected as a result of the examination requirements in Section 4, Tables 4-1 through 4-6, as well as criteria for expanding examinations to the Expansion components when warranted by the level of degradation detected in the Primary components.

Examination acceptance criteria identify the visual examination relevant condition(s) or signal-based level or relevance of an indication that requires formal disposition for acceptability. Based on the identified condition, and supplemental examinations if required, the disposition process results in an evaluation and determination of whether to accept the condition until the next examination or repair or replace the item. An acceptable disposition process is described in Section 6 and in Reference 26. Section 5.1 provides a discussion of relevant conditions applicable to the visual examination methods and of relevant indications applicable to the volumetric examinations employed in the guidelines. Section 5.2 provides examination acceptance criteria for physical measurements. These criteria are contained in Tables 5-1, 5-2, and 5-3 for B&W, CE, and Westinghouse plants, respectively.

Additionally, Tables 5-1, 5-2, and 5-3 contain expansion criteria for B&W, CE, and Westinghouse plants, respectively. Expansion criteria are intended to form the basis for decisions about expanding the set of components selected for examination or other aging management activity, in order to determine whether the level of degradation represented by the detected conditions has extended to other components judged to be less affected by the degradation.

Table 5-1
B&W plants examination acceptance and expansion criteria

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Plenum Cover Assembly & Core Support Shield Assembly Plenum cover weldment rib pads Plenum cover support flange CSS top flange	All plants	One-time physical measurement. In addition, a visual (VT-3) examination is conducted for these items. The measured differential height from the top of the plenum rib pads to the vessel seating surface shall average less than 0.004 inches compared to the as-built condition. The specific relevant condition for these items is wear that may lead to a loss of function.	None	N/A	N/A
Core Support Shield Assembly CSS vent valve top retaining ring CSS vent valve bottom retaining ring	All plants	Visual (VT-3) examination. The specific relevant condition is evidence of damaged or fractured retaining ring material, and missing items.	None	N/A	N/A
Control Rod Guide Tube Assembly CRGT spacer castings	All plants	The specific relevant condition for the VT-3 of the CRGT spacer castings is evidence of fractured spacers or missing screws.	None	N/A	N/A

Table 5-1
B&W plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Support Shield Assembly Upper core barrel (UCB) bolts and their locking devices	All plants	1) Volumetric (UT) examination of the UCB bolts. The examination acceptance criteria for the UT of the UCB bolts shall be established as part of the examination technical justification. 2) Visual (VT-3) examination of the UCB bolt locking devices. The specific relevant condition for the VT-3 of the UCB bolt locking devices is evidence of broken or missing bolt locking devices.	UTS bolts and LTS bolts or studs/nuts and their locking devices SSHT studs/nuts or bolts and their locking devices (CR-3 and DB only) Lower grid shock pad bolts and their locking devices (TMI-1 only)	1) Confirmed unacceptable indications exceeding 10% of the UCB bolts shall require that the UT examination be expanded by the completion of the next refueling outage to include: *For all plants* 100% of the accessible UTS bolts and 100% of the accessible LTS bolts or studs/nuts, *Additionally for TMI-1* 100% of the accessible lower grid shock pad bolts, *Additionally for CR-3 and DB* 100% of the accessible SSHT studs/nuts or bolts. 2) Confirmed evidence of relevant conditions exceeding 10% of the UCB bolt locking devices shall require that the VT-3 examination be expanded by the completion of the next refueling outage to include: *For all plants* 100% of the accessible UTS bolt and 100% of the accessible LTS bolt or stud/nut locking devices, *Additionally for TMI-1* 100% of the accessible lower grid shock pad bolt locking devices, *Additionally for CR-3 and DB* 100% of the accessible SSHT bolt or stud/nut locking devices.	1) The examination acceptance criteria for the UT of the expansion bolting shall be established as part of the examination technical justification. 2) The specific relevant condition for the VT-3 of the expansion locking devices is evidence of broken or missing bolt locking devices.

Table 5-1
B&W plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Barrel Assembly Lower core barrel (LCB) bolts and their locking devices	All plants	1) Volumetric (UT) examination of the LCB bolts. The examination acceptance criteria for the UT of the LCB bolts shall be established as part of the examination technical justification. 2) Visual (VT-3) examination of the LCB bolt locking devices. The specific relevant condition for the VT-3 of the LCB bolt locking devices is evidence of broken or missing bolt locking devices.	UTS bolts and LTS bolts or studs/nuts and their locking devices SSHT studs/nuts or bolts and their locking devices (CR-3 and DB only) Lower grid shock pad bolts and their locking devices (TMI-1 only)	1) Confirmed unacceptable indications exceeding 10% of the LCB bolts shall require that the UT examination be expanded by the completion of the next refueling outage to include: _For all plants_ 100% of the accessible UTS bolts and 100% of the accessible LTS bolts or studs/nuts _Additionally for TMI-1_ 100% of the accessible lower grid shock pad bolts, _Additionally for CR-3 and DB_ 100% of the accessible SSHT studs/nuts or bolts. 2) Confirmed evidence of relevant conditions exceeding 10% of the LCB bolt locking devices shall require that the VT-3 examination be expanded by the completion of the next refueling outage to include: _For all plants_ 100% of the accessible UTS bolts and 100% of the accessible LTS bolt or stud/nut locking devices, _Additionally for TMI-1_ 100% of the accessible lower grid shock pad bolt locking devices, _Additionally for CR-3 and DB,_ 100% of the accessible SSHT stud/nut or bolt locking devices.	1) The examination acceptance criteria for the UT of the expansion bolting shall be established as part of the examination technical justification. 2) The specific relevant condition for the VT-3 of the expansion locking devices is evidence of broken or missing bolt locking devices.

Table 5-1
B&W plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Barrel Assembly Baffle-to-former bolts	All plants	Baseline volumetric (UT) examination of the baffle-to-former bolts. The examination acceptance criteria for the UT of the baffle-to-former bolts shall be established as part of the examination technical justification.	Baffle-to-baffle bolts, Core barrel-to-former bolts	Confirmed unacceptable indications in greater than or equal to 5% (or 43) of the baffle-to-former bolts, provided that none of the unacceptable bolts are on former elevations 3, 4, and 5, or greater than 25% of the bolts on a single baffle plate, shall require an evaluation of the internal baffle-to-baffle bolts for the purpose of determining whether to examine or replace the internal baffle-to-baffle bolts. The evaluation may include external baffle-to-baffle bolts and core barrel-to-former bolts for the purpose of determining whether to replace them.	N/A
Core Barrel Assembly Baffle plates	All plants	Visual (VT-3) examination. The specific relevant condition is readily detectable cracking in the baffle plates.	a. Former plates b. Core barrel cylinder (including vertical and circumferential seam welds)	a and b. Confirmed cracking in multiple (2 or more) locations in the baffle plates shall require expansion, with continued operation of former plates and the core barrel cylinder justified by evaluation or by replacement by the completion of the next refueling outage.	a and b. N/A

Table 5-1
B&W plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Barrel Assembly Locking devices, including locking welds, of baffle-to-former bolts and internal baffle-to-baffle bolts	All plants	Visual (VT-3) examination. The specific relevant condition is missing, non-functional, or removed locking devices, including locking welds.	Locking devices, including locking welds, for the external baffle-to-baffle bolts and core barrel-to-former bolts	Confirmed relevant conditions in greater than or equal to 1% (or 11) of the baffle-to-former or internal baffle-to-baffle bolt locking devices, including locking welds, shall require an evaluation of the external baffle-to-baffle and core barrel-to-former bolt locking devices for the purpose of determining continued operation or replacement.	N/A
Lower Grid Assembly Alloy X-750 dowel-to-guide block welds	All plants	Initial visual (VT-3) examination. The specific relevant condition is separated or missing locking weld, or missing dowel.	Alloy X-750 dowel locking welds to the upper and lower grid fuel assembly support pads	Confirmed evidence of relevant conditions at two or more locations shall require that the VT-3 examination be expanded to include the Alloy X-750 dowel locking welds to the upper and lower grid fuel assembly support pads by the completion of the next refueling outage.	The specific relevant condition for the VT-3 of the expansion dowel locking weld is separated or missing locking weld, or missing dowel.

Table 5-1
B&W plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Flow Distributor Assembly Flow distributor (FD) bolts and their locking devices	All plants	1) Volumetric (UT) examination of the FD bolts. The examination acceptance criteria for the UT of the FD bolts shall be established as part of the examination technical justification. 2) Visual (VT-3) examination of the FD bolt locking devices. The specific relevant condition for the VT-3 of the FD bolt locking devices is evidence of broken or missing bolt locking devices.	UTS bolts and LTS bolts or studs/nuts and their locking devices SSHT studs/nuts or bolts and their locking devices (CR-3 and DB only) Lower grid shock pad bolts and their locking devices (TMI-1 only)	1) Confirmed unacceptable indications exceeding 10% of the FD bolts shall require that the UT examination be expanded by the completion of the next refueling outage to include: *For all plants* 100% of the accessible UTS bolts and 100% of the accessible LTS bolts or studs/nuts *Additionally for TMI-1* 100% of the accessible lower grid shock pad bolts, *Additionally for CR-3 and DB* 100% of the accessible SSHT studs/nuts or bolts. 2) Confirmed evidence of relevant conditions exceeding 10% of the FD bolt locking devices shall require that the VT-3 examination be expanded by the completion of the next refueling outage to include: *For all plants* 100% of the accessible UTS bolts and 100% of the accessible LTS bolt or stud/nut locking devices, *Additionally for TMI-1* 100% of the accessible lower grid shock pad bolt locking devices, *Additionally for CR-3 and DB,* 100% of the accessible SSHT stud/nut or bolt locking devices.	1) The examination acceptance criteria for the UT of the expansion bolting shall be established as part of the examination technical justification. 2) The specific relevant condition for the VT-3 of the expansion locking devices is evidence of broken or missing bolt locking devices.

Table 5-1
B&W plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Incore Monitoring Instrumentation (IMI) Guide Tube Assembly IMI guide tube spiders IMI guide tube spider-to-lower grid rib section welds	All plants	Initial visual (VT-3) examination. The specific relevant conditions for the IMI guide tube spiders are fractured or missing spider arms. The specific relevant conditions for the IMI spider-to-lower grid rib section welds are separated or missing welds.	Lower fuel grid assembly support pad items: pad, pad-to-rib section welds, Alloy X-750 dowel, cap screw, and their locking welds	Confirmed evidence of relevant conditions at two or more IMI guide tube spider locations or IMI guide tube spider-to-lower grid rib section welds shall require that the VT-3 examination be expanded to include lower fuel assembly support pad items by the completion of the next refueling outage.	The specific relevant conditions for the VT-3 of the lower grid fuel assembly support pad items (pads, pad-to-rib section welds, Alloy X-750 dowels, cap screws, and their locking welds) are separated or missing welds, missing support pads, dowels, cap screws and locking welds, or misalignment of the support pads.

Notes to Table 5-1:

1. The examination acceptance criterion for visual examination is the absence of the specified relevant condition(s).

Table 5-2
CE plants examination acceptance and expansion criteria

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Shroud Assembly (Bolted) Core shroud bolts	Bolted plant designs	Volumetric (UT) examination. The examination acceptance criteria for the UT of the core shroud bolts shall be established as part of the examination technical justification.	a. Core support column bolts b. Barrel-shroud bolts	a. Confirmation that >5% of the core shroud bolts in the four plates at the largest distance from the core contain unacceptable indications shall require UT examination of the lower support column bolts barrel within the next 3 refueling cycles. b. Confirmation that >5% of the core support column bolts contain unacceptable indications shall require UT examination of the barrel-shroud bolts within the next 3 refueling cycles.	a and b. The examination acceptance criteria for the UT of the core support column bolts and barrel-shroud bolts shall be established as part of the examination technical justification.
Core Shroud Assembly (Welded) Core shroud plate-former plate weld	Plant designs with core shrouds assembled in two vertical sections	Visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	Remaining axial welds	Confirmation that a surface-breaking indication > 2 inches in length has been detected and sized in the core shroud plate-former plate weld at the core shroud re-entrant corners (as visible from the core side of the shroud), within 6 inches of the central flange and horizontal stiffeners, shall require EVT-1 examination of all remaining axial welds by the completion of the next refueling outage.	The specific relevant condition is a detectable crack-like surface indication.

Table 5-2
CE plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Shroud Assembly (Welded) Shroud plates	Plant designs with core shrouds assembled with full-height shroud plates	Visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	a. Remaining axial welds b. Ribs and rings	a. Confirmation that a surface-breaking indication > 2 inches in length has been detected and sized in the axial weld seams at the core shroud re-entrant corners at the core mid-plane shall require EVT-1 or UT examination of all remaining axial welds by the completion of the next refueling outage. b. If extensive cracking is detected in the remaining axial welds, an EVT-1 examination shall be required of all accessible rib and ring welds by the completion of the next refueling outage.	The specific relevant condition is a detectable crack-like surface indication.

Table 5-2
CE plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Shroud Assembly (Bolted) Assembly	Bolted plant designs	Visual (VT-3) examination. The specific relevant conditions are evidence of abnormal interaction with fuel assemblies, gaps along high fluence shroud plate joints, and vertical displacement of shroud plates near high fluence joints.	None	N/A	N/A
Core Shroud Assembly (Welded) Assembly	Plant designs with core shrouds assembled in two vertical sections	Visual (VT-1) examination. The specific relevant condition is evidence of physical separation between the upper and lower core shroud sections.	None	N/A	N/A

Table 5-2
CE plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Support Barrel Assembly Upper (core support barrel) flange weld	All plants	Visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	Lower core support beams Upper core barrel cylinder (including welds) Upper core barrel flange	Confirmation that a surface-breaking indication >2 inches in length has been detected and sized in the upper flange weld shall require that an EVT-1 examination of the lower core support beams, upper core barrel cylinder and upper core barrel flange be performed by the completion of the next refueling outage.	The specific relevant condition is a detectable crack-like surface indication.
Core Support Barrel Assembly Lower cylinder girth welds	All plants	Visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	Lower cylinder axial welds	Confirmation that a surface-breaking indication >2 inches in length has been detected and sized in the lower cylinder girth weld shall require an EVT-1 examination of all accessible lower cylinder axial welds by the completion of the next refueling outage.	The specific relevant condition for the expansion lower cylinder axial welds is a detectable crack-like surface indication.
Lower Support Structure Core support column welds	All plants	Visual (VT-3) examination. The specific relevant condition is missing or separated welds.	None	None	

Table 5-2
CE plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Support Barrel Assembly Lower flange weld	All plants	Visual (EVT-1) examination. The specific relevant condition is a detectable crack-like indication.	None	N/A	N/A
Lower Support Structure Core support plate	All plants with a core support plate	Visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	None	N/A	N/A
Upper Internals Assembly Fuel alignment plate	All plants with core shrouds assembled with full-height shroud plates	Visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	None	N/A	N/A

Table 5-2
CE plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Control Element Assembly Instrument guide tubes	All plants with instruments tubes in the CEA shroud assembly	Visual (VT-3) examination. The specific relevant conditions are missing supports and separation at the welded joint between the tubes and the supports.	Remaining instrument tubes within the CEA shroud assemblies	Confirmed evidence of missing supports or separation at the welded joint between the tubes and supports shall require the visual (VT-3) examination to be expanded to the remaining instrument tubes within the CEA shroud assemblies by completion of the next refueling outage.	The specific relevant conditions are missing supports and separation at the welded joint between the tubes and the supports.
Lower Support Structure Deep beams	All plants with core shrouds assembled with full-height shroud plates	Visual (EVT-1) examination. The specific relevant condition is a detectable crack-like indication.	None	N/A	N/A

Notes to Table 5-2:
1. The examination acceptance criterion for visual examination is the absence of the specified relevant condition(s).

Table 5-3
Westinghouse plants examination acceptance and expansion criteria

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Control Rod Guide Tube Assembly Guide plates (cards)	All plants	Visual (VT-3) examination. The specific relevant condition is wear that could lead to loss of control rod alignment and impede control assembly insertion.	None	N/A	N/A
Control Rod Guide Tube Assembly Lower flange welds	All plants	Enhanced visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	a. Bottom-mounted instrumentation (BMI) column bodies b. Lower support column bodies (cast), upper core plate and lower support forging or casting	a. Confirmation of surface-breaking indications in two or more CRGT lower flange welds, combined with flux thimble insertion/withdrawal difficulty, shall require visual (VT-3) examination of BMI column bodies by the completion of the next refueling outage. b. Confirmation of surface-breaking indications in two or more CRGT lower flange welds shall require EVT-1 examination of cast lower support column bodies, upper core plate and lower support forging/castings within three fuel cycles following the initial observation.	a. For BMI column bodies, the specific relevant condition for the VT-3 examination is completely fractured column bodies. b. For cast lower support column bodies, upper core plate and lower support forging/castings, the specific relevant condition is a detectable crack-like surface indication.

Table 5-3
Westinghouse plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Barrel Assembly Upper core barrel flange weld	All plants	Periodic enhanced visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	a. Core barrel outlet nozzle welds b. Lower support column bodies (non cast)	a. The confirmed detection and sizing of a surface-breaking indication with a length greater than two inches in the upper core barrel flange weld shall require that the EVT-1 examination be expanded to include the core barrel outlet nozzle welds by the completion of the next refueling outage. b. If extensive cracking in the core barrel outlet nozzle welds is detected, EVT-1 examination shall be expanded to include the upper six inches of the accessible surfaces of the non-cast lower support column bodies within three fuel cycles following the initial observation.	a and b. The specific relevant condition for the expansion core barrel outlet nozzle weld and lower support column body examination is a detectable crack-like surface indication.
Core Barrel Assembly Lower core barrel flange weld (Note 2)	All plants	Periodic enhanced visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	None	None	None

Table 5-3
Westinghouse plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Core Barrel Assembly Upper core barrel cylinder girth welds	All plants	Periodic enhanced visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	Upper core barrel cylinder axial welds	The confirmed detection and sizing of a surface-breaking indication with a length greater than two inches in the upper core barrel cylinder girth welds shall require that the EVT-1 examination be expanded to include the upper core barrel cylinder axial welds by the completion of the next refueling outage.	The specific relevant condition for the expansion upper core barrel cylinder axial weld examination is a detectable crack-like surface indication.
Core Barrel Assembly Lower core barrel cylinder girth welds	All plants	Periodic enhanced visual (EVT-1) examination. The specific relevant condition is a detectable crack-like surface indication.	Lower core barrel cylinder axial welds	The confirmed detection and sizing of a surface-breaking indication with a length greater than two inches in the lower core barrel cylinder girth welds shall require that the EVT-1 examination be expanded to include the lower core barrel cylinder axial welds by the completion of the next refueling outage.	The specific relevant condition for the expansion lower core barrel cylinder axial weld examination is a detectable crack-like surface indication.

Table 5-3
Westinghouse plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Baffle-Former Assembly Baffle-edge bolts	All plants with baffle-edge bolts	Visual (VT-3) examination. The specific relevant conditions are missing or broken locking devices, failed or missing bolts, and protrusion of bolt heads.	None	N/A	N/A
Baffle-Former Assembly Baffle-former bolts	All plants	Volumetric (UT) examination. The examination acceptance criteria for the UT of the baffle-former bolts shall be established as part of the examination technical justification.	a. Lower support column bolts b. Barrel-former bolts	a. Confirmation that more than 5% of the baffle-former bolts actually examined on the four baffle plates at the largest distance from the core (presumed to be the lowest dose locations) contain unacceptable indications shall require UT examination of the lower support column bolts within the next three fuel cycles. b. Confirmation that more than 5% of the lower support column bolts actually examined contain unacceptable indications shall require UT examination of the barrel-former bolts.	a and b. The examination acceptance criteria for the UT of the lower support column bolts and the barrel-former bolts shall be established as part of the examination technical justification.

Table 5-3
Westinghouse plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Baffle-Former Assembly Assembly	All plants	Visual (VT-3) examination. The specific relevant conditions are evidence of abnormal interaction with fuel assemblies, gaps along high fluence shroud plate joints, vertical displacement of shroud plates near high fluence joints, and broken or damaged edge bolt locking systems along high fluence baffle plate joints.	None	N/A	N/A
Alignment and Interfacing Components Internals hold down spring	All plants with 304 stainless steel hold down springs	Direct physical measurement of spring height. The examination acceptance criterion for this measurement is that the remaining compressible height of the spring shall provide hold-down forces within the plant-specific design tolerance.	None	N/A	N/A

Table 5-3
Westinghouse plants examination acceptance and expansion criteria (continued)

Item	Applicability	Examination Acceptance Criteria (Note 1)	Expansion Link(s)	Expansion Criteria	Additional Examination Acceptance Criteria
Thermal Shield Assembly Thermal shield flexures	All plants with thermal shields	Visual (VT-3) examination. The specific relevant conditions for thermal shield flexures are excessive wear, fracture, or complete separation.	None	N/A	N/A

Notes to Table 5-3:
1. The examination acceptance criterion for visual examination is the absence of the specified relevant condition(s).
2. The lower core barrel flange weld may alternatively be designated as the core barrel-to-support plate weld in some Westinghouse plant designs.

5.1 Examination Acceptance Criteria

5.1.1 Visual (VT-3) Examination

Visual (VT-3) examination has been determined to be an appropriate NDE method for the detection of general degradation conditions in many of the susceptible components. The ASME Code Section XI, Examination Category B-N-3 [2], provides a set of relevant conditions for the visual (VT-3) examination of removable core support structures in IWB-3520.2. These are:

1. structural distortion or displacement of parts to the extent that component function may be impaired;
2. loose, missing, cracked, or fractured parts, bolting, or fasteners;
3. corrosion or erosion that reduces the nominal section thickness by more than 5%;
4. wear of mating surfaces that may lead to loss of function; and
5. structural degradation of interior attachments such that the original cross-sectional area is reduced more than 5%.

For components in the Existing Programs group, these general relevant conditions are sufficient. However, for components where visual (VT-3) is specified in the Primary or the Expansion group, more specific descriptions of the relevant conditions are provided in Tables 5-1, 5-2, and 5-3 for the benefit of the examiners. Typical examples are "fractured material" and "completely separated material." One or more of these specific relevant condition descriptions may be applicable to the Primary and Expansion components listed in Tables 5-1, 5-2, and 5-3.

The examination acceptance criteria for components requiring visual (VT-3) examination is thus the absence of the relevant condition(s) specified in Tables 5-1, 5-2, and 5-3.

The disposition can include a supplementary examination to further characterize the relevant condition, an engineering evaluation to show that the component is capable of continued operation with a known relevant condition, or repair/replacement to remediate the relevant condition.

5.1.2 Visual (VT-1) Examination

Visual (VT-1) examination is defined in the ASME Code Section XI [2] as an examination "conducted to detect discontinuities and imperfections on the surface of components, including such conditions as cracks, wear, corrosion, or erosion." For these guidelines VT-1 has only been selected to detect distortion as evidenced by small gaps between the upper-to-lower mating surfaces of CE welded core shrouds assembled in two vertical sections.

The examination acceptance criterion is thus the absence of the relevant condition of gaps that would be indicative of distortion from void swelling.

5.1.3 Enhanced Visual (EVT-1) Examination

Enhanced visual (EVT-1) examination has the same requirements as the ASME Code Section XI [2] visual (VT-1) examination, with additional requirements given in the Inspection Standard [3]. These enhancements are intended to improve the detection and characterization of discontinuities taking into account the remote visual aspect of reactor internals examinations. As a result, EVT-1 examinations are capable of detecting small surface breaking cracks and surface crack length sizing when used in conjunction with sizing aids (e.g. landmarks, ruler, and tape measure). EVT-1 examination has been selected to be the appropriate NDE method for detection of cracking in plates or their welded joints. Thus the relevant condition applied for EVT-1 examination is the same as found for cracking in Reference 2 which is crack-like surface breaking indications.

Therefore, until such time as generic engineering studies develop the basis by which a quantitative amount of degradation can be shown to be tolerable for the specific component, any relevant condition is to be dispositioned. In the interim, the examination acceptance criterion is thus the absence of any detectable surface breaking indication.

5.1.4 Surface Examination

Surface ET (eddy current) examination is specified as an alternative or as a supplement to visual examinations. No specific acceptance criteria for surface (ET) examination of PWR internals locations are provided in the ASME Code Section XI [2]. Since surface ET is employed as a signal-based examination, a technical justification per the Inspection Standard [3] provides the basis for detection and length sizing of surface-breaking or near-surface cracks. The signal-based relevant indication for surface (ET) is thus the same as the relevant condition for enhanced visual (EVT-1) examination. The acceptance criteria for enhanced visual (EVT-1) examinations in 5.1.3 (and accompanying entries in Tables 5-1, 5-2, and 5-3) are therefore applied when this method is used as an alternative or supplement to visual examination.

5.1.5 Volumetric Examination

The intent of volumetric examinations specified for bolts or pins in Section 4.3 of these I&E guidelines is to detect planar defects. No flaw sizing measurements are recorded or assumed in the acceptance or rejection of individual bolts or pins. Individual bolts or pins are accepted based on the detection of relevant indications established as part of the examination technical justification. When a relevant indication is detected in the cross-sectional area of the bolt or pin, it is assumed to be non-functional and the indication is recorded. A bolt or pin that passes the criterion of the examination is assumed to be functional.

Because of this pass/fail acceptance of individual bolts or pins, the examination acceptance criterion for volumetric (UT) examination of bolts and pins is based on a reliable detection of indications as established by the individual technical justification for the proposed examination. This is in keeping with current industry practice. For example, planar flaws on the order of 30% of the cross-sectional area have been demonstrated to be reliably detectable in previous bolt NDE technical justifications for baffle-former bolting.

Bolted and pinned assemblies are evaluated for acceptance based on meeting a specified number and distribution of functional bolts and pins. As discussed in Section 6.4, criteria for this evaluation can be: 1) found in previous Owners Group reports, 2) developed for use by the PWROG or 3) developed on a plant-specific basis by the applicable NSSS vendor.

5.2 Physical Measurements Examination Acceptance Criteria

Continued functionality can be confirmed by physical measurements where, for example, loss of material caused by wear, loss of pre-load of clamping force caused by various degradation mechanisms, or distortion/deflection caused by void swelling may occur. Where appropriate, these physical measurements are described in Section 4.3, with limits applicable to the various designs. For B&W designs, the acceptable tolerance for the measured differential height from the top of the plenum rib pads to the vessel seating surface has been generically established and is provided in Table 5-1. For Westinghouse designs, tolerances are available on a design or plant-specific basis and thus are not provided generically in these guidelines. For CE designs, no physical measurements are specified.

5.3 Expansion Criteria

The criteria for expanding the scope of examination from the Primary components to their linked Expansion components is contained in Tables 5-1, 5-2, and 5-3 for B&W, CE, and Westinghouse plants, respectively. The logic and basis for the levels of degradation warranting expansion is documented in an MRP letter [15].

6 EVALUATION METHODOLOGIES

There are various options that are available for the disposition of conditions detected during examinations (Section 4) that are unable to satisfy the examination acceptance criteria (Section 5). These options include, but are not limited to: (1) supplemental examinations, such as a surface examination, to supplement a visual (VT-1) or an enhanced visual (EVT-1) examination, to further characterize and potentially dispose of a detected condition; (2) engineering evaluation that demonstrates the acceptability of a detected condition; (3) repair, in order to restore a component with a detected condition to acceptable status; or (4) replacement of a component with an unacceptable detected condition.

The first option involves the re-examination of a component with an unacceptable detected condition with an alternative examination method that has the potential capability to further define or confirm with greater precision the component physical condition. This additional characterization may enable the more precise character of that detected condition to be found acceptable for continued service. An example would be the volumetric (UT) examination to depth size a surface-breaking flaw detected by either visual (VT-1) or enhanced visual (EVT-1) examination.

Section 6 concentrates on the second option, evaluation methodologies that can be used for evaluating flaws detected during the examinations described in Section 4 that exceed the examination acceptance criteria described in Section 5. The guidance provided in this section is general; Reference 26 should be consulted for more detailed guidance.

The evaluation process depends upon the loading applied to the component, assembly, or system. Typical loading information to be considered is provided in Section 6.1 and evaluation methodology options are described in subsequent sections. These methodologies range from the satisfaction of limit load requirements for the internals assembly or component cross section to the satisfaction of flaw stability requirements using either linear elastic fracture mechanics (LEFM) or elastic-plastic fracture mechanics (EPFM), depending upon applicability. In addition, recommendations for flaw depth assumptions, in the absence of flaw depth sizing during examination, and flaw growth assumptions for subsequent operation until the next examination, are described. Justification for flaw evaluation fracture toughness limits is also provided. Design-specific or fleet-specific flaw handbooks may be used as an engineering evaluation tool.

6.1 Loading Conditions

The purpose of this section is to describe the typical loading conditions that govern the evaluation of flaws exceeding the examination acceptance criteria of Section 5.

Core support structures are designed to a set of defined loading conditions that typically include deadweight, such as the weight of the structure itself and an assigned portion of the weight of the fuel assemblies; mechanical loads, such as fuel assembly spring forces and control rod actuation loads; hydraulic loads; loadings caused by flow-induced vibration; loss-of-coolant accident (LOCA) loads; thermal loads, such as those from both normal operation thermal transients and upset condition thermal transients, as well as gamma heating; operating basis earthquake (OBE) and safe shutdown earthquake (SSE) seismic loads; handling loads that might occur during refueling and internals removal for inservice examinations; and interference conditions, friction forces, and dynamic insertion loads. Confirmation of required loading and combination requirements on an individual plant basis is essential prior to conducting any assessment.

For the case of many bolts and pins, the defined loading conditions include interference conditions, friction forces due to differential thermal growth, and dynamic insertion loads, in addition to dead weight, seismic, and vibration loadings.

The loading conditions for internal structures that are not core support structures are less well documented publicly. However, should an engineering evaluation be required for any internals structure (both core support structures and other internals), the original design basis should be examined, in order to determine the availability of actual or potential loading conditions.

6.2 Evaluation Requirements

The evaluation of component conditions that do not satisfy the examination acceptance criteria of Section 5 must be performed for a future state that corresponds to the next required examination or later. This future state should be determined based on the observed condition and a projection of future condition based on progressing degradation. The progressing degradation estimate should be based on a combination of operating experience (bolt failure histories), applicable testing data (crack growth rates in plate material), and available analytical results for that component. Uncertainties in predictive measures should be considered where applicable. Options for performing evaluations are contained in the following sub-sections.

6.2.1 Limit Load Evaluation

Evaluation Requirement

An assembly or component that cannot meet the examination acceptance criteria of Section 5 of these I&E guidelines may be subject to limit load requirements as an evaluation disposition option, in order to continue in service in the existing condition. For PWR internals, the threshold for limit load requirements only is based on the accumulated neutron fluence exposure identified in BWRVIP-100-A [19]. This requirement states that, for accumulated neutron fluence less than $3x10^{20}$ n/cm^2 (E > 1 MeV), or approximately 0.5 dpa, only a limit load evaluation requirement must be met for continued service of the internals assembly or individual component. A discussion and explanation of this requirement is contained in the following paragraphs.

Discussion and Explanation

Irrespective of the level of neutron irradiation exposure, limit load requirements can be satisfied for the affected assembly or component, in order to continue service until the end of the current inservice inspection interval. Therefore, the affected assembly or component can be shown to satisfy limit load requirements which may follow procedures similar to those given in the ASME Code Section XI, Appendix C [20]. The limit load calculation is carried out to find the critical degree of degradation within the elements of the assembly, or the progress of flaw parameters (location of the remaining cross section neutral axis and the effective flaw length) that cause the cross section to reach its limit load. For austenitic stainless steel, the stress limits for primary loading may be based on the irradiated mechanical strength properties for the minimum estimated fluence accumulated at the loaded section.

A safety factor of 2.77 on the limit load for expected loadings (ASME Service Loadings A and B) and a safety factor of 1.39 on the limit load for unexpected loadings (ASME Service Loadings C and D) must be met for the applied load on the assembly, or on the membrane and bending stresses in the component. The component analysis must demonstrate that a plastic hinge does not form in the remaining ligament of the cross section. For sections that have relatively uniform loss of material, and for unflawed sections that experience increased loading due to failure in other sections, the limiting primary stress and deflections for ASME Level C and D combinations should meet the plant design basis, or alternatively, meet the requirements of ASME Section III, Appendix F [21].

If the neutron fluence exposure is less than $3x10^{20}$ n/cm^2 (E > 1 MeV), or approximately 0.5 dpa, this is the only evaluation that needs to be met for acceptance of the PWR internals assembly or individual component. No fracture toughness requirements need to be met for neutron fluence exposures less than this value.

6.2.2 Fracture Mechanics Evaluation

For neutron fluence levels exceeding 0.5 dpa, either an elastic-plastic fracture mechanics (EPFM) evaluation or a linear elastic fracture mechanics (LEFM) evaluation must be performed to assure continued structural integrity in the presence of detected flaws that exceed the examination acceptance criteria of Section 5. For neutron fluence above 0.5 dpa and below 5 dpa, EPFM is the preferred method. For neutron fluence above 5 dpa, LEFM should be utilized. Non-mandatory Appendix C of the ASME Code Section XI [20] provides general guidance which may be followed for performing such evaluations. Although the appendix strictly applies to austenitic stainless steel piping, the discussion of flaw growth due to fatigue, or due to stress corrosion cracking (SCC), or due to a combination of the two is relevant. Note, however, that fatigue crack growth rates in Article C-8000 are limited to air environments only, and that fatigue crack growth in water environments and SCC crack growth rates are not available yet.

For the case of IASCC, considerable research has been conducted on the effects of various levels of irradiation exposure on crack growth resistance, primarily by the Boiling Water Reactor Vessel & Internals Project (BWRVIP) [19]. Reference 19 also provides the technical basis for the recommendation of either LEFM or EPFM. Figure 6-1, reproduced from Reference 19, shows the data that were used to produce a set of conservative J-R curves (crack growth resistance curves) for various exposure levels. Figures 6-2 and 6-3, also reproduced from Reference 19, show the lower bound for the power law parameter, C, and the upper bound for the power law parameter, n, in the curve fit to the crack growth resistance curve data given by

$J_{mat} = C(\Delta a)^n$ **Equation 6-1**

where J and C are in KJ/m^2 and Δa is in mm.

The lower bound expression for power law parameter C is given by

$C = (1217.9*6.697*10^{10} + 0.3908*F^{0.5563})/(6.697*10^{10} + F^{0.5563})$ **Equation 6-2**

The upper bound expression for power law parameter n is given by

$n = 1/(4.962 - 0.02439*F^{0.09976})$ **Equation 6-3**

The term F in the above expressions is the neutron fluence. At accumulated fluence values of approximately 1 dpa, the material has relatively high elastic-plastic crack growth resistance. For example, at 1 dpa, the upper bound power law parameter C equals 177 and the lower bound power law parameter n equals 0.492. Then, the crack growth resistance at 1.5 mm of crack growth is 216 KJ/m^2. Elastic-plastic behavior would be expected at such a low fluence level.

At an accumulated fluence value of 10 dpa, C equals 55.2 and n equals 0.7833. Then, the crack growth resistance at 1.5 mm of crack growth is 75.8 KJ/m^2. If the tangent to the crack growth resistance curve at 1.5 mm is projected back to zero crack growth and converted to K_I through the expression

$J_{IC} = (K_{IC})^2/E$ **Equation 6-4**

where E is the elastic modulus, then K_{IC} equals 100 $MPa\sqrt{m}$. This value of fracture toughness is in the range that would suggest that LEFM is perhaps more suitable than EPFM, even though some amount of plastic response remains.

However, at 15 dpa, C equals 44.54 and n equals 0.889, so that the crack growth resistance at 1.5 mm of crack growth is only 64 KJ/m^2. Extrapolating the tangent of the crack growth resistance curve back to zero crack growth and converting gives $K_{IC} = 92$ $MPa\sqrt{m}$. Further analysis of more recent fracture toughness data at higher irradiation exposures for irradiated stainless steels has determined [25] that an appropriately conservative value for the fracture toughness of 38 $MPa\sqrt{m}$ should be used for high neutron fluence exposure.

Therefore, for fluence levels below 5 dpa, the elastic-plastic crack growth resistance curves based on Equations 6-1 to 6-3 should be used. For neutron fluence greater than 5 dpa, LEFM analyses should be used with a limiting fracture toughness $K_{IC} = 55$ $MPa\sqrt{m}$ for exposure levels between 5 and 15 dpa, and with a limiting fracture toughness $K_{IC} = 38$ $MPa\sqrt{m}$ for exposure levels greater than 15 dpa.

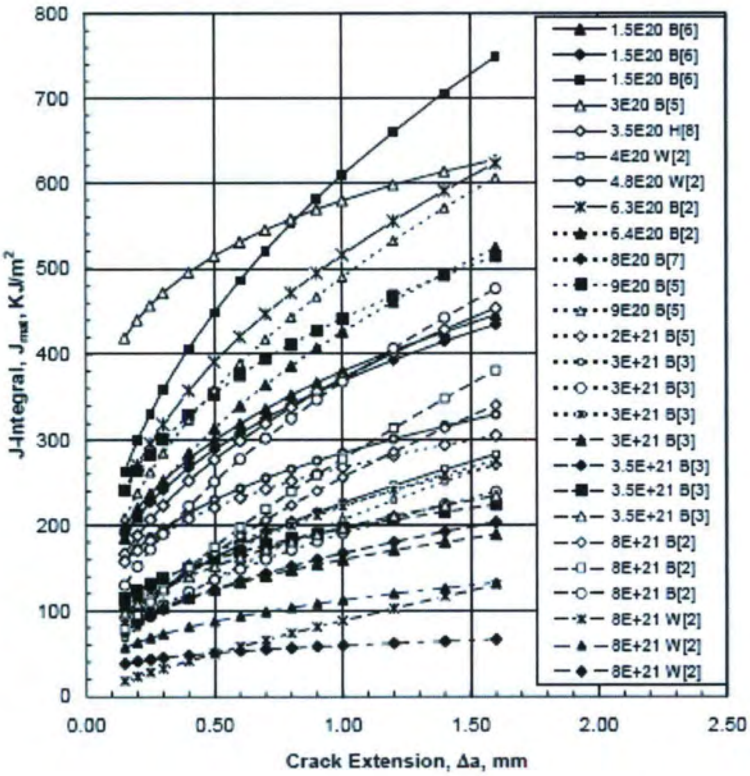


Figure 6-1
Experimental $J_{material}$ versus crack extension curves for stainless steel materials at various fluence levels [19]

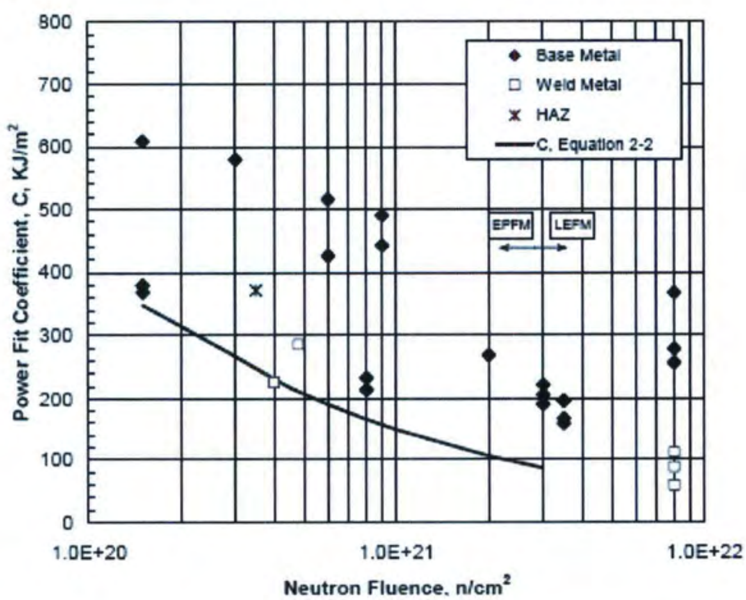


Figure 6-2
J-R curve power law parameter C as a function of neutron fluence for stainless steel, applicable for fluence less than $3x10^{21}$ n/cm^2 [19]

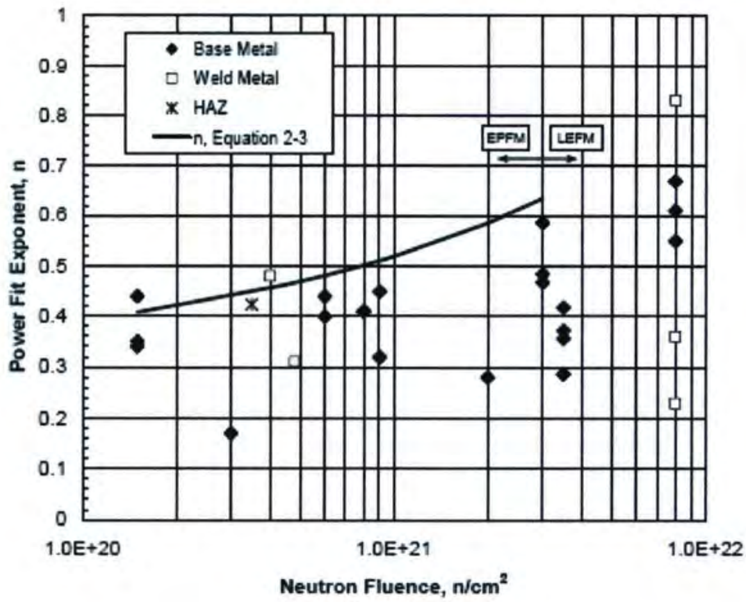


Figure 6-3
J-R curve power law parameter n as a function of neutron fluence for stainless steel, applicable for fluence less than $3x10^{21}$ n/cm^2 [19]

6.2.3 Flaw Depth Assumptions

If the flaw depth has been determined by either the primary examination or by a supplementary examination method, that flaw depth should be used in any subsequent flaw evaluation. If only the flaw length has been determined by the examination, the evaluation should be based on the assumption that the flaw extends completely through the cross section of the component. The evaluation may be based on an assumption of depth if justified by a sufficiently robust technical demonstration.

6.2.4 Crack Growth Assumptions

Prior to the limit load and fracture mechanics calculations, the cyclic and time-dependent flaw growth from the current time to the next examination must be calculated. For example, if the inservice inspection interval is ten years, the flaw growth must be calculated for a ten-year period. If the examination is a one-time examination only, the growth of the flaw to the end of component life must be calculated and shown to satisfy acceptable limits. If the end-of-period flaw exceeds limits, the inservice inspection interval should be adjusted and a subsequent inspection performed prior to exceeding the flaw limit.

In the absence of sufficient information on crack growth in relevant PWR environments, data from BWR hydrogen water chemistry (HWC) environments is the most electrochemically appropriate and readily available source. A crack growth rate of $1.1x10^{-5}$ inches per hour (2.5 mm/year) in the depth direction has been accepted by the NRC staff for BWR HWC environments in their safety evaluation of BWRVIP-14 [23]. This assumed flaw growth rate may be too conservative for a PWR water environment; therefore, the technical basis for reduced flaw growth rates is discussed in the following paragraphs.

The most recent information on flaw growth rates for irradiated austenitic stainless steels in BWR environments is provided in BWRVIP-99 [24]. The information in BWRVIP-99 is based on both laboratory data and on field measurements of crack growth rates in BWR core shroud beltline welds, as measured by ultrasonic testing. The data are considered proprietary. The major findings were that field-measured crack growth rates varied from $2x10^{-6}$ to $5.25x10^{-5}$ inches per hour (about 0.5 mm to 11 mm per year), with the crack growth rate as a function of depth much lower than the crack growth rate as a function of length. Laboratory crack growth rates depended upon electro-chemical potential (ECP), with the growth rates substantially lower in a HWC environment that is more typical of a PWR environment. The HWC crack growth rates varied from $1x10^{-7}$ to $4x10^{-5}$ inches per hour (0.02 mm to 9 mm per year). The nominal reduction in crack growth rate for the HWC environment was found to be approximately 20 times lower than the corresponding crack growth rates in nominal BWR environments. However, the scatter in the data is very large.

For HWC environments, the recommended curve is given by

$$da/dt = 2.72 \times 10^{-8} (K)^{2.5}$$ **Equation 6-5**

Figure 6-4 shows that this curve approximates an upper bound to the relevant laboratory HWC data.

The BWR HWC curve is seen to be representative for PWR water environments, compared to limited crack growth rate data in PWR environment shown in Figure 6-5 [25]. Therefore, the HWC curve may be used for all PWR IASCC and SCC analyses until generic curves are established for IASCC and SCC in PWR environment. The use of alternative crack growth rate correlations in any analysis must be accompanied by an appropriate technical justification.

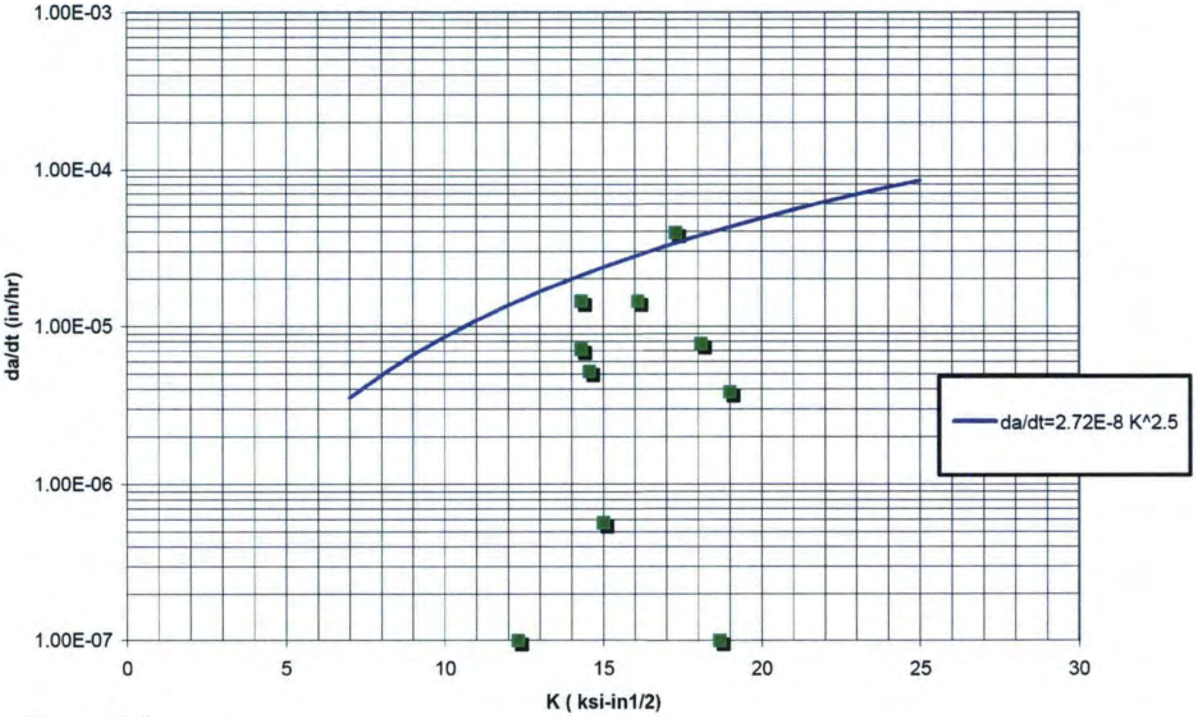


Figure 6-4
Proposed BWR hydrogen water chemistry crack growth curves for stainless steel irradiated between $5x10^{20}$ to $3x10^{21}$ n/cm^2 [24]

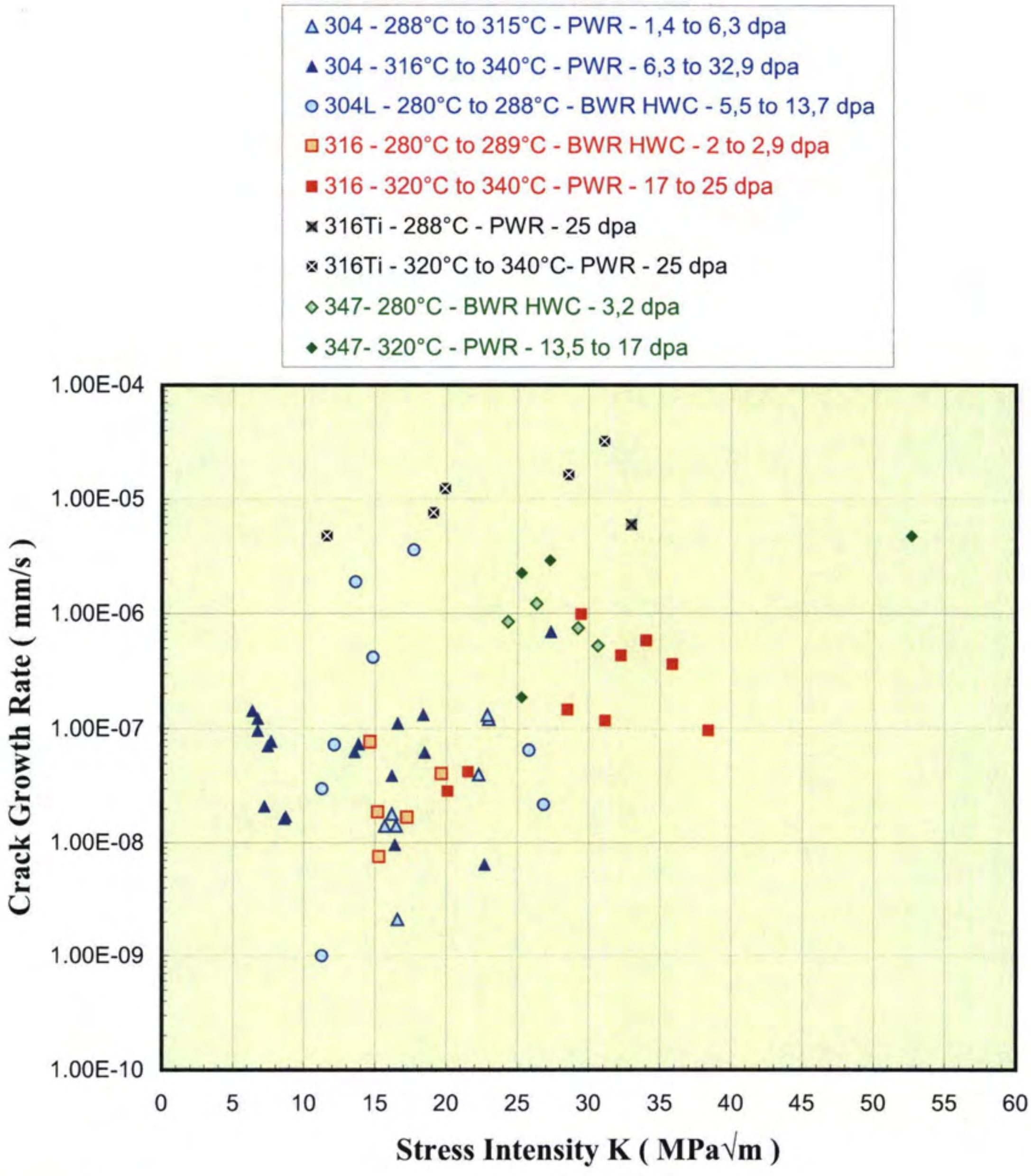


Figure 6-5
Effect of stress intensity on IASCC crack growth rate [25]

6.3 Evaluation of Flaws in Bolts and Pins

For bolts and pins, no evaluation of individual items is required. Individual bolts or pins that are found to be unacceptable during the UT examination should be assumed to be non-functional, and the acceptance criterion for continued operation of the assembly that contains one or more non-functional bolts or pins are based on the functioning of the assembly, not the individual bolt or pin. In addition, no evaluation of individual items is required where visual examinations are the basis for determining functionality of bolts, pins or locking devices. Assessments in cases where the assembly is found to be deficient are most often driven by loose parts or reassembly interference evaluations that may be resolved using standard processes to support continued operation. Typically these are part of existing plant corrective action programs and as such should be sufficient to disposition.

6.4 Assembly Level Evaluations

As indicated in Sections 5.1.5, bolts are not accepted or rejected based on flaw sizing but on flaw detection. Thus the bolted assembly must be evaluated based on the number of rejected bolts, the minimum number required for functionality and an assumed failure rate until the next examination. Assemblies that satisfy an evaluation criterion that has been established by the NSSS vendor may be dispositioned. Alternatively, an assembly level evaluation may be performed to ensure that required functionality is maintained through the period until the next examination. Essential features of this type of evaluation are described below.

A process that can be followed for those system level evaluations is provided in the following paragraphs. The process builds on the vendor functionality evaluations [11, 12]. Other approaches can also be used. The finite element models to be used for the system level evaluation could take advantage of geometric and loading symmetry. Examples of such models have been demonstrated for the B&W-designed and Westinghouse-designed baffle-former assemblies, the CE-designed core shroud assembly, and bottom core plate assemblies for different vendor designs. The bolts and pins that are elements of the assembly should be modeled in sufficient detail to capture the essential structural behavior needed to demonstrate function or the lack thereof. For example, the assumption that a particular bolt, pin, or fastener has failed can be accounted for by modeling the bolt or pin as a one-dimensional finite element with no axial or shear strength. If a particular bolt or pin is assumed to maintain at least some or most of its preload, then the representation of material strength must be appropriate. That material strength should account conservatively for the local fluence and temperature for particular bolts or pins. The geometric modeling of the bolts and pins for system level evaluations does not require the level of detail that would be needed to predict localized failure in a bolt or pin.

The number of bolts or pins that are assumed to be non-functional should bound the estimated number and pattern of non-functional bolts or pins at the end of the evaluation interval. The estimation process is beyond the scope of this document. A conservative pattern that differs from the actual observed pattern of non-functional bolts or pins may be used. The loads referred to in Section 6.1 should be applied to this assembly model, and the structural response determined. This structural response should then be compared to assembly functional requirements, and a determination should be made about the capability to continue to operate the assembly through the remainder of the inspection interval.

The precise functionality criteria for each assembly are beyond the scope of this document. Reference should be made to vendor-recommended criteria.

6.5 Evaluation of Flaws in Other Internals Structures

Reference 22 describes a methodology to be used to evaluate detected and sized flaws found in PWR internals – other than bolts or pins – that exceed the examination acceptance criteria in Section 5.1. This methodology is summarized in the following steps.

First, the neutron fluence for the component is calculated or derived from existing calculations.

Second, the applied stresses are found from either existing stress analyses or from a new stress analysis of the assembly containing the affected component location.

Third, the detected and sized flaw from the examination is applied to a representation of the geometry of interest. Reference 22 has provided a number of representative PWR internal core support geometries of interest.

Fourth, the growth of the flaw over the period of time until the next examination, or until the end of component life, as applicable, is calculated. The flaw growth calculation will depend on the active mechanism driving the flaw extension (i.e. IASCC, SCC, or fatigue). Reference 22 assumed that negligible flaw growth occurred prior to application of nominal, design-basis, and bounding loads.

Fifth, load evaluation requirements (for example, limit load) for the flawed geometry after flaw growth, subject to both expected and unexpected loads, should be met.

Sixth, applied fracture mechanics stress intensities or applied J-integrals are calculated from the combination of the stresses and the grown flaws for the representative core support geometry of interest, as applicable. LEFM solutions may be obtained from the literature, with a conversion to an elastic-plastic crack driving force valid for localized plasticity at the crack tip.

Finally, the applied fracture mechanics stress intensities or the applied J-integrals must be shown to meet the limits of Section 6.2.2. For LEFM calculations, the applied fracture mechanics stress intensity must be shown to be less than the material fracture toughness. For EPFM calculation, the evaluation procedure specified in ASME Section XI, non-mandatory Appendix K, Article K-4000, K-4220 [2], can be used to demonstrate flaw stability. Specifically, Paragraph K-4220 provides a flaw stability criterion that limits the elastic-plastic crack driving force to less than the material elastic-plastic crack growth resistance at a crack extension of 0.1 inches. The safety margin that is demonstrated in meeting the limits of Section 6.2.2 should be identified and justified for the classes of loading considered.

The methodology outlined above has been demonstrated in Reference 22, where five simple geometries were analyzed with assumed dimensions that represented a wide variety of PWR internals locations. Because of the uncertainty in the applied stresses and the conservatism of the bounding material fracture toughness, no safety margins were applied to the critical flaw size calculations. The five simple geometries analyzed are described below:

- A semi-elliptical surface crack in a flat plate that can represent: (i) a semi-elliptical surface crack at the inside or outside flat surface of baffle plates; (ii) a semi-elliptical surface crack at the inside or outside flat surface of a core support barrel; or (iii) a semi-elliptical surface crack at the inside or outside surface of a core barrel. The flaw can be either circumferential (e.g., in the circumferential weld seam of the core barrel) or longitudinal (e.g., in the vertical weld seam). A flat plate solution is adequate for these cylinders when the radius to thickness ratio (R/t) is greater than 36 and loading level is fairly low;
- A through-wall crack in the center of a plate that can represent: (i) a through-wall crack in baffle plates; (ii) a through-wall crack in the flat surface of a core support barrel; (iii) a circumferential through-wall crack (e.g. in the circumferential weld seam) in a core barrel; or (iv) a longitudinal through-wall crack (e.g. in the vertical weld seam) in a core barrel;

- A through-wall edge crack in a flat plate that can represent: (i) a through-wall crack emanating from the side edges of baffle plates; or (ii) a through-wall crack emanating from the edge of former plates;
- A through-wall edge crack emanating from a 1 and 3/8-inch diameter hole that can represent: (i) two through-wall edge cracks emanating from baffle-to-former bolt holes or cooling holes; or (ii) two through-wall edge cracks emanating from holes in former plates; and
- A quarter-circular corner crack in a rectangular bar that can represent: (i) a quarter-circular crack in the corner of baffle plates; or (ii) a quarter-circular crack at the inside corner of a core support barrel.

Although no detailed loading/stress information was available for the various geometries, limited information was used to estimate the maximum normal operating stress (2.5 ksi) and the maximum LOCA stress (10 ksi) in highly irradiated components. For completeness, however, remote tensile stress levels up to 50 ksi were analyzed.

For the three types of postulated through-wall flaws, the analyses showed that the critical flaw is more limiting for a through-wall edge crack or a through-wall edge crack emanating from a hole than for a through-wall centered crack. For a medium-width baffle plate (26-inch), the critical flaw length for a through-wall crack is 22.8 inches at 2.5 ksi and 7.62 inches at 10 ksi. For the same baffle plate, the critical flaw length for a through-wall edge crack is 11.3 inches at 2.5 ksi and 2.65 inches at 10 ksi.