

Table showing BWR “Core Shroud Cracking” Problems

Sorted by “Commercial operation since”

BWRVIP	MWe Netto	Nuclear Suplyer	BWR	Mark	Commercial Operation since	Country	core shroud cracking found	Repairs	Inspection Method	Tie Rod Cracking	Core Shroud steel
Nine Mile Point 1	615	GE	5	1	1969	USA	>93	fixed with 4 tie rods		Yes	
Oyster Creek	610	GE	2	1	1969	USA	>93				
Tsuruga 1	357	GE	2	1	1969	Japan	94	Core Shroud Replaced Mar. 2001			
Dresden 2	772	GE	3	1	1970	USA	>93	fixed with tie rods		Yes	
Fukushima Daiichi I-1	439	GE	3	1	1970	Japan	93	Core Shroud Replaced Nov 01			SUS304
Mühleberg	355	GE	4	1	1971	CH	90	fixed with tie rods 1997			SS 304
Dresden 3	773	GE	3	1	1971	USA	94			Yes	
Millstone 1	641	GE	3	1	1971	USA	>93	Permanent Shutdown 1998			
Monticello	536	GE	3	1	1971	USA	>93				
Santa Maria de Garona	446	GE	3	1	1971	Spain	>93				
Würgassen	640	AEG/KWU			1971	BRD	1994	Permanent Shutdown 1994			347
Onagawa 1	524	Toshiba	4	1	1971	Japan	2002				304L
Oskarshamn 1	445	ASEA-Atom	ASEA	2	1971	Sweden	1994	Core Shroud Replaced 1998			347
Pilgrim	685	GE	3	1	1972	USA	>93	fixed with tie rods		Yes	
Vermont Yankee	504	GE	4	1	1972	USA	>93	1996: Core shroud fixed with 4 tie rods			
Quad Cities 1	769	GE	3	1	1973	USA	94	fixed with tie rods		Yes	
Quad Cities 2	769	GE	3	1	1973	USA	>93	fixed with tie rods		Yes	
Susquehanna 1	1040	GE	4	2	1973	USA	1997				304L
Susquehanna 2	1040	GE	4	2	1973	USA	>93				
Fukushima Daiichi I-2	760	GE	4	1	1973	Japan	94	Core Shroud Replaced Aug 99			SUS304
Shimane 1	439	Hitachi	4	1	1973	Japan	94	Core Shroud Replaced April 01			
Hatch 1	741	GE	4	1	1974	USA	>93	fixed with tie rods		Yes	
Peach Bottom 2	1055	GE	4	1	1974	USA	>93				
Peach Bottom 3	1035	GE	4	1	1974	USA	>93				
Fukushima Daiichi I-3	760	Toshiba	4	1	1974	Japan	94	Core Shroud Replaced Sept. 98			SUS304
Brunswick 2	754	GE	4	1	1975	USA	>93				304
Fitzpatrick	780	GE	4	1	1975	USA	>93	fixed with tie rods			
Hamaoka 1	515	Toshiba	4	1	1976	Japan	>93	Core Shroud Replacement planed			
Brunswick 1	767	GE	4	1	1977	USA	93	“two weld repair”			304

Fukushima Daiichi I-5	760	Toshiba	4	1	1977	Japan	94	Core Shroud Replaced Oct. 2000			SUS304
Chin-Shan 1	604	GE	4	1	1978	Taiwan	>93				
Hamaoka 2	806	Toshiba	4	1	1978	Japan	>93	Core Shroud Replacement planed			
Fukushima Daiichi I-4	760	Hitachi	4	1	1978	Japan	1993				304L
Chin-Shan 2	604	GE	4	1	1979	Taiwan	1995				304L
Hatch 2	883	GE	4	1	1979	USA	1994			Yes	304L
Fukushima Daini II-2	1067	Hittachi	5	2	1979	Japan	1994	fixed with tie rods 2002			316L
Forsmark 1	968	ASEA-Atom	ASEA	3	1980	Sweden	Cracks found	Core Shroud Replaced 2000			
Forsmark 2	969	ASEA-Atom	ASEA	3	1981	Sweden	Cracks found	Core Shroud Replaced 2000			
La Salle 1	1036	GE	5	2	1984	USA	>93				
La Salle 2	1036	GE	5	2	1984	USA	>93				
Onagawa 2	1067	Toshiba	5	1A	1984	Japan	>93	fixed with tie rods 2005			
Fukushima Daini II -3	1067	Hitachi	5	2A	1984	Japan	1997	fixed with tie rods 2001			316L
Cofrentes	1064	GE	6	3	1985	Spain	1997				304L
Grand Gulf	1143	GE	6	3	1985	USA	>93				
Kashiwazaki 1	1067	Toshiba	5	2	1985	Japan	1994				316L
Fukushima Daini II -4	1067	Hitachi	5	2A	1986	Japan	1995				316L
Clinton	930	GE	6	3	1987	USA	>93	fixed with tie rods		Yes	
Hamaoka 3	1056	Toshiba	5	1A	1987	Japan		fixed with tie rods 2005			
Kashiwazaki 2	1067	Toshiba	5	2A	1990	Japan	2002				316L
Kashiwazaki 3	1067	Toshiba	5	2A	1992	Japan	2002				316L
Hamaoka 4	1092	Toshiba	5	1A	1993	Japan	2002	fixed with tie rods 2006			316L
				A=Advanced							

Table showing BWR, Core Shroud “without” Cracking Problems

BWRVIP	MWe	Nuclear Supplier	BWR	Mark	Commercial Operation since	Country	core shroud cracking found	Inspection	Core Shroud steel
Leibstadt	1000	GE	6	3	1984	Switzerland			
Browns Ferry 1	1065	GE	4	1	1973	USA		Areva Ultrasonic	
Browns Ferry 2	1065	GE	4	1	1974	USA		Areva Ultrasonic	
Browns Ferry 3	1065	GE	4	1	1976	USA		Areva Ultrasonic	
Cooper Station	760			1		USA			
Duane Arnold	540			1		USA			
Fermi 2	1075			1		USA			
Hope Creek 1	1030			1		USA			
Hope Creek 2	1030			1		USA			
Quad Cities 1	770			1		USA			
Quad Cities 2	770			1		USA			
Brunsbüttel							UP to 2005 none found		1.4550
Isar 1							UP to 2005 none found		1.4550
Phillipsburg 1							UP to 2005 none found		1.4550
Krümmel							UP to 2005 none found		1.4550
Grundremmingen B							UP to 2005 none found		1.4550
Grundremmingen C							UP to 2005 none found		1.4550
Tarapur TAPS						India	UP to 1999 none found		AISI 304

Data in upper Table based on Information in Links Below.

More than 30 reactors affected worldwide
 Materials: AISI 304, 304L, 347, 316L
[12_Gerard_R\[1\].pdf](#)

<http://nuclear-history.org/issues.html> To this point tie rods have been installed at Hatch 1, FitzPatrick, Nine Mile Point, Pilgrim, Quad Cities 2, Hatch 2, Dresden 2, and Quad Cities 1.

<http://carn7.best.vwh.net/tekbrefs/sib96138/SIB96138r2.htm>
 January 1998 SIB-96-138, Rev. 1, BWR Reactor Internals Cracking
 Core Shroud Cracking Evaluations

In the Summer of 1993, while in the process of performing an in-vessel visual inspection (IVVI) of the core shroud at Brunswick, Unit 1, Carolina Power & Light Company personnel discovered extensive cracking at weld H3 (see Figure 1). GE Nuclear Energy (GE) was contracted to evaluate the degraded condition, and SI was retained to provide third party review of GE's evaluations. When it was discovered that the cracking was more extensive and deeper than originally anticipated, GE was contracted to develop a repair for welds H2 and H3, with SI again providing a third party review function. A "two weld repair" was implemented in December of 1993, and the Brunswick unit returned to power in the Spring of 1994.

After the "two weld repair" was implemented at Brunswick, Unit 1, a number of repair vendors embarked upon concepts which could repair all shroud circumferential welds. To date, both GE and MPR Associates/Framatome Technologies have implemented core shroud repairs.

Since the Summer of 1993, SI has been involved with the core shroud cracking issue at Brunswick 1, Units 1 and 2, Chin-Shan, Units 1 and 2 (Taiwan), Cofrentes (Spain), Dresden, Units 2 and 3, FitzPatrick, Grand Gulf, Hatch, Units 1 and 2, LaSalle, Units 1 and 2, Millstone, Unit 1, Monticello, Nine Mile Point, Unit 1, Oyster Creek, Peach Bottom, Units 2 and 3, Pilgrim, Quad Cities, Units 1 and 2, Santa Maria de Garofia (Spain), Susquehanna, Units 1 and 2, and Vermont Yankee.

Like the core shroud cracking issue, SI's involvement with reactor internal core spray system cracking is again in three areas:

Since the middle of 1995, SI has been involved with core spray system cracking issues at Brunswick, Unit 2, Dresden, Units 2 and 3, FitzPatrick, Millstone, Unit 1, Peach Bottom, Unit 3, and Vermont Yankee. Because of this recent involvement, and our involvement with the BWRVIP on this subject (as discussed below), SI is well suited to provide detailed support in this area.

To date, SI's involvement has focused on three components. SI has designed a riser brace repair for Dresden, Unit 3, performed qualitative set screw gap evaluations for Peach Bottom, Units 2 and 3, and Dresden, Units 2 and 3, performed quantitative set screw gap analyses for Pilgrim and Cooper, and performed third party review of the riser pipe cracking at Hatch, Unit 1 and Peach Bottom, Unit 3.

Other Internals Cracking Evaluations

Since the end of 1994, SI has also been involved with the cracking of other BWR reactor internal components. SI has evaluated access hole cover cracking at Pilgrim, top guide cracking at Oyster Creek, steam dryer drain channel cracking at Susquehanna, Units 1 and 2, and provided an independent review of the work performed by GE to determine the structural capability of the core plate hold down bolts at Nine Mile Point, Unit 1. Support to the BWRVIP

http://www-pub.iaea.org/MTCD/publications/PDF/te_1471_web.pdf

To date, the core shrouds made of 304 stainless steel were replaced as SCC countermeasure in Tokyo Electric Power Company Fukushima Dai-ichi Nuclear Power Station Unit 1,2,3,5, Chugoku Electric Power Company Shimane Nuclear Power Station Unit 1 and Japan Atomic Power Company Tsuruga Nuclear Power Station Unit 1 [6.45].

<http://www.nrc.gov/reading-rm/doc-collections/event-status/event/2006/20061011en.html>

BWR CORE SHROUD TIE ROD UPPER SUPPORT CRACKING

Affected US Plants per Attachments 1 and 2 of the Part 21 notification: Clinton, Nine Mile Point 1, Pilgrim, Dresden 2 & 3, Quad Cities 1 & 2, Hatch 1 & 2.

<http://www.icjt.org/plants> Plant Information Size, Operational, Supplier ...

Kernmantelrisse entdeckt!

http://iws.tugraz.at/IWS_tree/Veranstalt/Tagungen/Download/Wtagung/Erve.pdf

http://www.ksu.se/publikationer/pdf/Engelsk_2000.pdf

<http://www.ecology.at/nni/index.php?p=site&s=210>

<http://www.nea.fr/html/rp/reports/2000/nea2728-isoe99-complete.pdf>

Core Shroud Replacement in Swedish Reactors

Reparatur NMP1

<http://www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/1997/in97017.html>

Zugstangen Patent

<http://www.wipo.int/ipdl/IPDL-IMAGES/PCT-PAGES/1997/401997/97034304/97034304.pdf>

Containment Typen Japan

<http://www.tepco.co.jp/en/corpinfo/overview/pdf-4/70-71-e.pdf>

Containment Typen Spanien

<http://www.nea.fr/html/nsd/docs/2002/csni-r2002-6.pdf>

Core Shroud and its Function Japan

<http://cnic.jp/english/newsletter/nit92/nit92articles/nit92shroud.html>

Hamaoka

<http://www2.jnes.go.jp/atom-db/en/trouble/individ/power/j/j20011108/j01b081b.pdf>

Kasiwashaki

<http://www-ns.iaea.org/downloads/coordination/snr-reg-meeting-2007/SRM2007-Fukushima2.pdf>

Containmenttypen in USA

<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/v18/sr1350v18.pdf>

Alle Containment typen Japan

<http://www.meti.go.jp/english/report/downloadfiles/NISAreport3e.pdf>

<http://www.structint.com/tekbrefs/sib96138/SIB96138r2.htm>

1993 Two Weld Repair at Brunswick

Since the Summer of 1993, SI has been involved with the core shroud cracking issue at Brunswick, Units 1 and 2, Chin-Shan, Units 1 and 2 (Taiwan), Cofrentes (Spain), Dresden, Units 2 and 3, FitzPatrick, Grand Gulf, Hatch, Units 1 and 2, LaSalle, Units 1 and 2, Millstone, Unit 1, Monticello, Nine Mile Point, Unit 1, Oyster Creek, Peach Bottom, Units 2 and 3, Pilgrim, Quad Cities, Units 1 and 2, Santa Maria de Garoña (Spain), Susquehanna, Units 1 and 2, and Vermont Yankee. In addition, SI performed a study for the Japanese Owner's Group on the repair concepts offered by three vendors; namely, GE, MPR Associates/Framatome Technologies and Siemens.

<http://www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/1997/in97017.html>

Muttern lose, Klammern gerissen.

http://www.svti.ch/pages/index.cfm?Artikel_ID=1426

Jahresberichte Nuklearinspektorat

<http://www10.antenna.nl/wise/index.html?http://www10.antenna.nl/wise/400-1/3908.html>

At issue is the carbon 304 series stainless steel used in the following BWR core shrouds in the US: Duane Arnold; Fermi 2; Hatch 1 and 2; WNP 2; Clinton; Brown's Ferry 1, 2, and 3; Fitzpatrick; Monticello; and Oyster Creek. Also of concern are Taiwan's Chinsan 1 and 2 and Kousheng 1 and 2. Three smaller cracks of the same type had also shut down the Unit 2 reactor at Brunswick this summer. **Source:** Nucleonics Week (US), 7 Oct. 1993, New York Times, 7 Oct. US, NRC Weekly Information Report, 1 Oct.