

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

July 23, 1993

NRC INFORMATION NOTICE 93-57: SOFTWARE PROBLEMS INVOLVING DIGITAL CONTROL  
CONSOLE SYSTEMS AT NON-POWER REACTORS

Addressees

All holders of operating licenses or construction permits for test and research reactors and nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to software problems involving digital control console systems at two non-power reactors. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

Armed Forces Radiobiology Research Institute (AFRRI)

On September 4, 1992, at the AFRRI Training Reactor and Isotope Production - General Atomics (TRIGA) reactor, a problem with the interlock logic for the digital control console was discovered during the performance of the items on the daily startup checklist for the shutdown reactor. The digital control console, manufactured by General Atomics, was installed at AFRRI in the summer of 1990 in accordance with an NRC license amendment dated July 23, 1990.

The problem was revealed when a trainee depressed the PULSE mode button and the rod UP button simultaneously and a control rod was driven out of the core. This rod movement was inconsistent with a rod withdrawal interlock for the PULSE mode of operation. The rod continued to withdraw even after the rod UP button was released; this continued withdrawal is inconsistent with the design intent of the rod control system. Licensee personnel manually tripped the reactor to stop the withdrawal of the control rod. The licensee investigated this event and found that the same rod withdrawal action would occur when the SQUARE WAVE mode button (instead of the PULSE mode button) and the rod UP button were depressed simultaneously. However, the problem would not occur when the AUTO mode button and the rod UP button were depressed simultaneously. The licensee tested a variety of interlock combinations for the digital control console system and did not find any other problems.

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This problem had not been discovered previously for two reasons: (1) General Atomics, the manufacturer of both the TRIGA reactor and the digital control console, considered the simultaneous pressing of the mode selector and rod UP buttons to be inconsistent with the operational design of the reactor, and (2) these buttons were so located on the control console that it was unusual for an operator to press both buttons simultaneously.

As an interim measure, pending a permanent modification, the licensee installed a switch configuration that required the operator to use both hands to enter the pulse or square-wave mode of operation. This change prevented an operator from pressing a rod UP button at the same time as an operational mode button.

General Atomics has now developed a permanent software modification for this problem, and the licensee installed the modification at AFRRRI on September 25, 1992. This modification was also installed at other facilities that have the General Atomics digital control consoles. The temporary solution for the digital control console at AFRRRI was maintained until the permanent software modification was fully tested and accepted.

#### Pennsylvania State University (Penn State)

On October 5, 1992, with the reactor shut down, operators at the Penn State TRIGA reactor erroneously assigned a positive value to a software parameter for their digital control console. Power was supplied to the control rod magnets at the time, engaging the control rods to their drive mechanisms and resulting in allowing control rod withdrawal on the demand signal from the control system which resulted from the software error. The error resulted in the unanticipated withdrawal of the transient control rod. The transient rod scrambled on a rod withdrawal overspeed trip.

Software subroutines in this system are typically designed to reject irrational parameter changes and issue warning messages. However, because this particular parameter has a wide range of valid positive and negative inputs, the software cannot prevent the operator from inputting erroneous values.

The digital control console, manufactured by Atomic Energy of Canada, Ltd., of Mississauga, Ontario, was installed at Penn State in the summer of 1991 in accordance with an NRC license amendment dated August 6, 1991. The manufacturer of the digital control console has discussed possible corrective actions with the licensee and with other customers who could experience the problem.

The licensee has instituted administrative controls at Penn State that are designed to prevent a recurrence of this type of problem. These administrative controls include (1) a requirement that power to the control rod magnets be off when making software changes, (2) increased management review of proposed changes, and (3) the use of design change procedures to

control changes to the digital control console, providing additional assurance that the software changes will be installed correctly and tested.

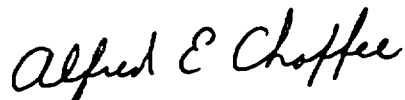
### Discussion

These problems, and the increasing number and wide variety of licensees and applications using digital technology, emphasize the importance of the design, testing, and change control of digital systems.

An effective verification and validation (V&V) plan for software that performs a safety function can help ensure acceptable design and implementation. Some acceptable V&V plans are described in Regulatory Guide 1.152, "Criteria for Programmable Digital Computer Software in Safety-Related Systems at Nuclear Power Plants," and in American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE) Standard 1012-1986, "IEEE Standard for Software Verification and Validation Plans." Guidance for determining the design specifications that are to be verified and validated is available in ANSI/IEEE Standard 830-1984, "IEEE Guide to Software Requirements Specification."

Another key element related to digital systems is the control of software configuration changes. Guidance for software configuration change control is available in ANSI/IEEE Standard 828-1983, "IEEE Standard for Software Configuration Management Plans."

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Brian K. Grimes, Director  
Division of Operating Reactor Support  
Office of Nuclear Reactor Regulation

Technical contacts: J. Stewart, NRR  
(301) 504-0824

W. Eresian, NRR  
(301) 504-1833

M. Mendonca, NRR  
(301) 504-1128

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List of Recently Issued NRC Information Notices

Attachment  
IN 93-57  
July 23, 1993  
Page 1 of 1

LIST OF RECENTLY ISSUED  
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
93-56	Weakness in Emergency Operating Procedures Found as Result of Steam Generator Tube Rupture	07/22/93	All holders of OLS or CPs for pressurized water reactors.
93-55	Potential Problem with Main Steamline Break Analysis for Main Steam Vaults/Tunnels	07/21/93	All holders of OLS or CPs for pressurized water reactors.
93-54	Motor-Operated Valve Actuator Thrust Variations Measured with A Torque Thrust Cell and A Strain Gage	07/20/93	All holders of OLS or CPs for nuclear power reactors.
93-53	Effect of Hurricane Andrew on Turkey Point Nuclear Generating Station and Lessons Learned	07/20/93	All holders of OLS or CPs for nuclear power reactors.
93-52	Draft NUREG-1477, "Voltage-Based Interim Plugging Criteria for Steam Generator Tubes"	07/14/93	All holders of OLS or CPs for pressurized water reactor (PWRs).
93-51	Repetitive Overspeed Tripping of Turbine-Driven Auxiliary Feed-water Pumps	07/09/93	All holders of OLS or CPs for nuclear power reactors.
93-50	Extended Storage of Sealed Sources	07/08/93	All licensees authorized to possess sealed sources.
93-49	Improper Integration of Software into Operating Practices	07/08/93	All holders of OLS or CPs for nuclear power reactors.

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**Brian K. Grimes**  
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Division of Operating Reactor Support  
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07/ /93	07/02/93	06/28/93	
*C/HICB:DRCH:NRR	*HICB:DRCH:NRR	*HICB:DRCH:NRR	*C/ONDD:DORS:NRR
JSWermeil	MChiramal	JCStewart	SHWeiss
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AJKugler	TechEd	EHylton	MMendonca
06/22/93	06/22/93	06/22/93	06/22/93
DOCUMENT NAME:	93-57.IN		

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*OGCB:DORS:NRR AJKugler 06/22/93	*RPB:ADM TechEd 06/22/93	*ONDD:DORS:NRR MMendonca 06/22/93
DOCUMENT NAME:	NONPOWER.IN	

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06/ /93	06/22/93	06/ /93	06/ /93

Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for further reducing reporting burden, to the Information and Records Management Branch (MNBB-7714), U.S. Nuclear Regulatory Commission, Washington, D.C. 20555; and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-3019, (3150-0009), Office of Management and Budget, Washington, D.C. 20503.

Further clarification to this bulletin is provided in the attached responses to specific questions raised by licensees.

If you have any questions about this matter, please contact the Operations Branch at (301) 504-3497.

Original Signed By: *E Ten Eyck for*

Robert F. Burnett, Director  
 Division of Fuel Cycle Safety  
 and Safeguards  
 Office of Nuclear Material Safety  
 and Safeguards

Attachments:

1. Questions and Answers to Bulletin 91-01
2. List of Recently Issued NMSS Bulletins
3. List of Recently Issued NRC Bulletins

EKraus 6/14/93 \*See previous concurrence

OFC	FCLB	N	FCLB	N	IMOB	E	FCLB		FCLB			
NAME	MKlasky*		VTharpe*		KRamsey*		MTokar*		CEmeigh*			
DATE	07/01/93		07/01/93		07/09/93		07/02/93		07/01/93			
OFC	FOCB*	E	FOCB*	E	DD:FCSS		D:FCSS		FCLB*	E		
NAME	SPennington		CNSmith		JGreeves*		RFBurnett*		BPierson			
DATE	07/20/93		07/21/93		07/02/93		07/14/93		07/21/93			

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Robert F. Burnett, Director  
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 Office of Nuclear Material Safety  
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EKraus 6/14/93 \*See previous concurrence

OFC	FCLB	N	FCLB	N	IMOB	E	FCLB		FCLB		FRIB	
NAME	MKlasky*		VTharpe*		KRamsey*		MTokar*		CEmeigh*		TSherr	
DATE	07/01/93		07/01/93		07/09/93		07/02/93		07/01/93			
OFC	FOCB <i>WPE</i>	<i>E</i>	FOCB <i>WPE</i>	<i>E</i>	DD:FCSS		D:FCSS <i>WPE</i>		FCLB	<i>E</i>		
NAME	SPennington		CNSmith <i>WPE</i>	<i>E</i>	JGreeves*		RFBurnett* <i>WPE</i>		BPierson			
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Although no specific request or requirement is intended, the following information would be helpful to the NRC in evaluating the cost of complying with this bulletin:

- (1) the licensee staff's time and costs to perform requested inspections, corrective actions, and associated testing
- (2) the licensee staff's time and costs to prepare the requested reports and documentation
- (3) the additional short-term costs incurred as a result of the inspection findings such as the costs of the corrective actions or the costs of down time
- (4) an estimate of the additional long-term costs which will be incurred in the future as a result of implementing commitments such as the estimated costs of conducting future inspections or increased maintenance

Further clarification to this bulletin is provided in the attached responses to specific questions raised by licensees.

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Robert F. Burnett, Director  
 Division of Fuel Cycle Safety  
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 Office of Nuclear Material Safety  
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Technical contact: Marc Klasky, NMSS  
 (301) 504-2504

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OFC	FCLB	N	FCLB	N	IMOB
NAME	MKlasky*		VTharpe*		KRamsey
DATE	7/01/93		7/01/93		7/9/93

OFC	FCLB*		FCLB	E	DD:FCSS*		D:FCSS
NAME	MTokar		CMeigh*		JGreeves		RBurnett
DATE	7/02/93		7/01/93		7/02/93		7/14/93

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NAME	MKlasky*		VTharpe*		KRamsey <sup>2MR</sup>	
DATE	7/01/93		7/01/93		7/9/93	

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OFC	FCLB*		FCLB	E	DD:FCSS*		D:FCSS	
NAME	MTokar		CEmeigh*		JGreeves		RBurnett	
DATE	7/02/93		7/01/93		7/02/93		7/ /93	

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NAME	MKlasky*		VTharpe*		KRamsey	
DATE	7/01/93		7/01/93		7/ /93	

OFC	<del>FCLB</del>		FCLB	E	DD:FCSS		D:FCSS	
NAME	MTokar		CMeigh*		JGreeves		RBurnett	
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Technical contacts: Marc Klasky, NMSS  
 (301) 504-2504

John Greeves, NMSS  
 (301) 504-3334

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OFC	FCLB	FCLB	FCLB	IMOB
NAME	MKlasky	RWilson	JHarpe	KRamsey
DATE	7/1/93	7/ /93	7/01/93	7/ /93
OFC	FCLB	FCLB	DD:FCSS	D:FCSS
NAME	MTokar	CEmeigh	JGreeves	RBurnett
DATE	7/ /93	7/ /93	7/ /93	7/ /93

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~~(Bulletin) (Information Notice)~~

(number)

" REPORTING LOSS OF CRITICALITY

(title)

SAFETY CONTROLS"

was issued on \_\_\_\_\_  
(date)

The technical contacts are MARC KLASKY, NMSS, ext. 504-2504  
~~J. H. ...~~ ~~504-2504~~  
ROBERT WILSON, ext. 504-2126

**Summary:**

The purpose of this document is to clarify the reporting requirements of Nuclear Regulatory Commission Bulletin 91-01.