NRC FORM 366 (6-1998) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104 EXPIRES 06/30/2001

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Three Mile Island, Unit 1	05000289	1 OF 10

TITLE (4)
VOLUNTARY LER REGARDING INCREASING FAILURE RATE OF ESAS RELAYS

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
										05000
05	28	99	99	-- 007 --	1	08	20	99	FACILITY NAME	DOCKET NUMBER 05000

OPERATING MODE (9):

POWER LEVEL (10):

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)

	20.2201(b)		20.2203(a)(2)(v)		50.73(a)(2)(i)		50.73(a)(2)(viii)
	20.2203(a)(1)		20.2203(a)(3)(i)		50.73(a)(2)(ii)		50.73(a)(2)(x)
	20.2203(a)(2)(i)		20.2203(a)(3)(ii)		50.73(a)(2)(iii)		73.71
	20.2203(a)(2)(ii)		20.2203(a)(4)		50.73(a)(2)(iv)	X	OTHER-Voluntary
	20.2203(a)(2)(iii)		50.36(c)(1)		50.73(a)(2)(v)		Specify in Abstract below or in NRC Form 366A
	20.2203(a)(2)(iv)		50.36(c)(2)		50.73(a)(2)(vii)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
Adam Miller, TMI Licensing Engineer	(717) 948-8128

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX
undetermined	BPI	RLY	C360	Y					

SUPPLEMENTAL REPORT EXPECTED (14)

				EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
	YES (If yes, complete EXPECTED SUBMISSION DATE).	X	No				

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

TMI-1 has seen a decrease in the reliability of Clark type PM relays used in the Engineered Safeguards Actuation System (ESAS). Clark type PM relays are commercial grade industrial relays that are dedicated for use in safety related systems by GPU Nuclear. Recent failures have highlighted the recurring problem characterized by coil overheating and failure to fully re-close after being de-energized. It has been decided to voluntarily notify the NRC of previously unrecognized age and wear related problems with these components.

The root cause of these failures has been determined to be inadequate preventative maintenance in that the frictional buildup from the gradual wear of moving parts and loosening of screws went uncorrected. This condition caused the moving components of the contact and actuator sections of the relay to occasionally bind while re-positioning to an energized state.

A long-term plan that addresses both the need to replace degraded relays as well as enhanced maintenance activities to improve relay performance has been established.

There were no adverse safety consequences from this event, and the event did not affect the health and safety of the public.

TEXT *(If more space is required, use additional copies of NRC Form 366A)* (17)

I. Plant Operating Conditions Before Event:

This voluntary LER documents an increase in failures in a system. TMI-1 was operating at both power and shutdown when individual failures occurred.

II. Status of Structures, Systems, or Components that were Inoperable at the Start of the Event and that Contributed to the Event:

None

III. Event Description:

TMI-1 has seen a decrease in the reliability of Clark type PM relays *[BP/RLY] used in the Engineered Safeguards Actuation System (ESAS).

The ESAS relays are designed to initiate plant Engineered Safeguards equipment and logic circuitry to accomplish safe shutdown, long term decay heat removal, and accident mitigation functions in the event a Limiting Safety System Setting is exceeded.

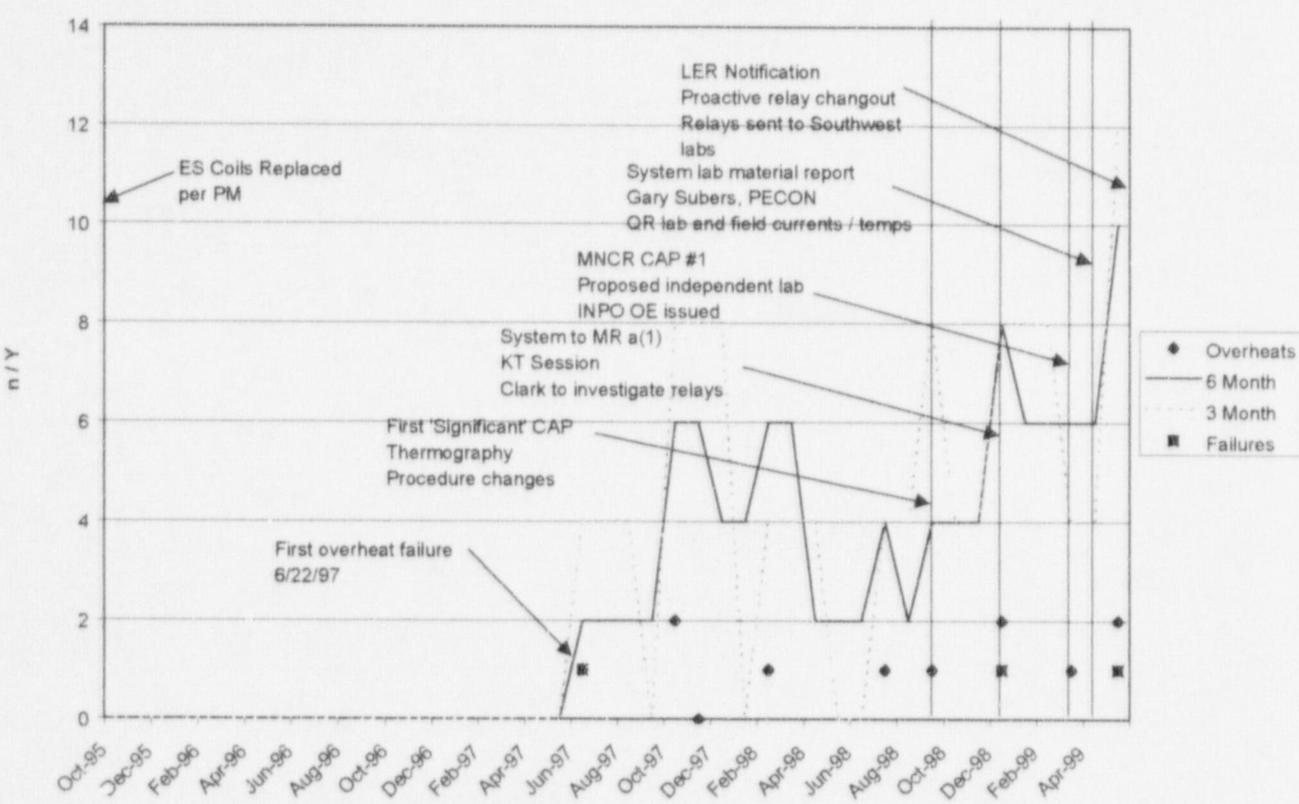
In all cases, the failures occurred as a de-energized relay has been called upon to energize. This typically occurs as a relay is de-energized (channel tripped) for surveillance testing, and is then re-energized to place it back in the armed state.

During initial operation, the ESAS relays performed unsatisfactorily with a record of failures until the relay solenoid coils and other sub-components were slightly re-designed to prevent sticking in the energized position. A replacement was performed in 1985 as a preventative measure to offset any potential age related degradation. The second service interval of the ESAS relays (1985-1995), was relatively free of significant problems with only one failure during this period. However, since the relay solenoid coils were again pro-actively replaced in 1995, a pattern of recurring failures began to emerge. Refer to the chart of relay failures on the following page.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Three Mile Island, Unit 1	05000289	99	-- 007 --	1	3 OF 10

TEXT *(If more space is required, use additional copies of NRC Form 366A)* (17)

ESAS Relay Overheat Rate



In the period from June 1997 to June 1999, a total of 11 relays have overheated, resulting in the requirement to replace the relay coils. In two cases the coils overheated to the extent where a small flame was evidenced and in one case overheating resulted in the coil opening.

Procedure changes have been made to have technicians check relays for signs of overheating following regularly scheduled surveillances that cycle ESAS relays.

Nine of the eleven relays affected used TB 130-1 coils, the strongest coils available for this variety of relay.

Ten of the eleven relays that overheated were in the fan-out to component logic in the ESAS Actuation cabinets, in normally energized applications. In this application, if the relay coil were to overheat to the point of failing open, the relay would travel to its actuated state. Failure in this state places the ESAS for the affected components in one out of two logic, instead of the usual 2/3 logic.

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The remaining failure caused operators to allow a channel to automatically enable on a plant heat-up, because the manual enable of the channel was inoperable. This failure had no safety significance.

IV. Assessment of the Safety Consequences and Implications of the Event:

Because of the design of the ESAS, failure of a single relay has few undesired effects. A failure of the relay that results in a train relay de-energizing results in the components affected by that relay to go to one out of two logic, increasing the likelihood of those components actuating. In most cases, however, the relays were discovered and assisted into the position that they should travel to when fully energized. This typically results in stopping the overheating condition, and allows the coils and potentially sticky magnet kit to be replaced during normal planned maintenance.

Design criteria (GDC 20 and GDC 41) requires the ability to mitigate a LOCA, with a single failure and a loss of offsite power. Any single ESAS relay failure can be tolerated without exception.

The increased failure rate results in increased operator and maintenance burden, and an increased chance of a partial ESAS actuation. Additionally ESAS has a requirement to be able to be bypassed following actuation during a postulated event, and the reduction in reliability slightly increases the possibility that this could not be accomplished in a timely manner.

TMI-1 technical specifications, licensing basis and the B&W Generic Technical specifications allow continuous operation with a single channel of ESAS actuated. Therefore there is no precedent on addressing this facet of continuous operation.

It has been identified, however that for certain accident scenarios there is the requirement to regain control of actuated components to maintain system operability following a LOCA. These include throttling High Pressure Injection, Low Pressure Injection, and Building Spray Systems. They also including transferring suction from the BWST to the RB sump on depletion of the BWST.

If a second failure were to affect another relay in the 2/3 logic, that component would actuate but not be bypassed. Should two relays in the same logic fail, the affected components would need to be defeated, and the appropriate component Tech Spec time clock entered. The other train of ESAS and ECCS, however would remain operable and fully functional.

The ESAS can also tolerate almost all second-failures in the opposite train with the exception of several relays. If the second failure were in the opposite train and a LOCA were to occur, the train with the failed relay would be able to actuate, and be bypassed for throttling as required. An example of this is a failure of DH-P-1A with 63Z1A/RC1B relay failure, resulting in 1/2 logic for DH-V-4B. Control of DH-V-4B would be available to throttle DH-P-1B to prevent runout.

The most limiting single failure for ESAS is a loss of DC, concurrent with a LOOP. In this case, a failure of a relay powered from Vital Bus A or Vital Bus C in the A train (an /RB1A, /RB3A, /RC1A or /RC1C relay) or a relay powered from Vital Bus B or Vital Bus D in the B train (an /RB2B, /RB3B, /RC2B or /RC3B relay) could affect both trains of ESAS. The train with the loss of DC would be inoperable. The components in the opposite train with the failed relay would actuate, but could not be bypassed without physical manipulation of the damaged relay, or the relay affected by the loss of Vital Bus.

V. Extent of Condition:

These recurring relay failures have only involved the normally energized ESAS relays with typically 10-14 contacts. No other site relays are exhibiting recurring failures. The other site relays are either normally de-energized or have fewer contacts being repositioned.

Although the details of each event are different, Joslyn-Clark type PM relays in the TMI-1 ESAS have been discovered overheating while buzzing, through a 'hot' smell, or when they start smoking. Typically, the relays are assisted into their 'enabled' state by lightly pressing the keeper at the bottom of the relay. Generally within 24 to 48 hours, the relay is placed into the tripped state, and partially disassembled to replace the coil and magnet kit.

The tables on the following page summarize the Joslyn-Clark relays that are used in the TMI-1 ESAS.

Table 1, Relays used in ESAS

	Use	Total number of relays	Manufacturer	State
1.	ESAS train relays (AC relays)	136	Joslyn-Clark	Normally energized
2.	ESAS manual actuation relays (DC relays)	46	Joslyn-Clark	Normally deenerzied
3.	ESAS channel logic and test relays	146	Joslyn-Clark	Energized or deenergized depending on plant conditions

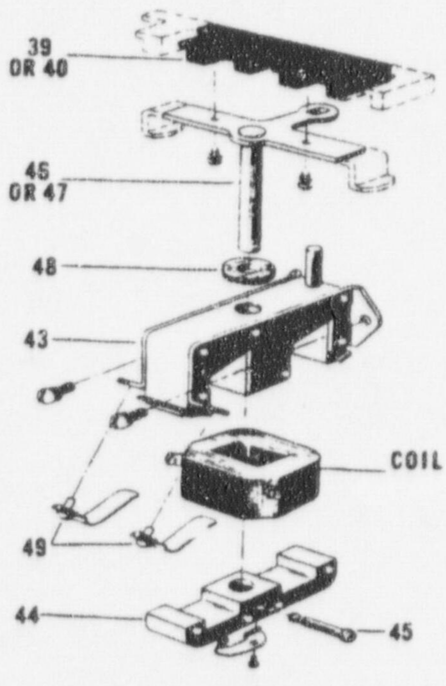
Table 2 summarizes the failures.

Table 2, ESAS relay failures

Date	Model #	Coil type	Relay designation	Notes
6/22/97	5U14-13	TB 130-1	63Z1B/RB2B	
10/1/97	5U10-9	TB 113-61	63Z/RC5A	This relay was cleaned only, no coil replacement
10/17/97	5U10-5	TB 113-61	43/RC6B	Did not allow channel 6B manual enable, automatically enabled at setpoint.
2/19/98	5U14-11	TB 130-1	63Z1B/RC1A	
7/31/98	5U14-6	TB 130-1	63Z2B/RC3A	
9/2/98	5U12-11	TB 130-1	62X2A/RC2A	
12/2/98	5U14-13	TB 130-1	63Z1B/RB2A	
12/4/98	5U14-13	TB 130-1	63Z1B/RB2B	Repeat failure
3/18/99	5U13-12	TB 130-1	63Z1B/RB1A	
5/14/99	5U14-13	TB 130-1	63Z2A/RC3B	
5/27/99	5U14-9	TB 130-1	63Z1A/RC3A	

VI. Component Data:

Clark type PM relays are commercial grade industrial relays that are dedicated for use in safety related systems by GPU Nuclear. The following diagram details the assembly of the magnet kit and coil. Up to fourteen removable contacts are ganged and mounted to part 39 and 46.



Contact Arm and Magnet and Rod Assembly

Reference Number	Description
40	Contact Arm, Long
41	Magnet and Rod Assembly, (Straight end bracket) including reference numbers 43, 44, 45, 47, 48 and 49
42	Magnet and Rod Assembly, (Hooked End Bracket) including reference numbers 43, 44, 45, 46, 48, and 49
43	Stationary Magnet Assembly
44	Armature Assembly (keeper)
45	Armature Pin
46	Bracket and rod assembly (Hooked ends)
47	Bracket and rod assembly (Straight ends)
48	Phenolic Washer
49	Coil Clamp Assembly

TMI utilizes part 42, not 41 in its ESAS relays.

VII. Previous Events of a Similar Nature

One failure of a relay coil occurred in the 1991 time frame. Prior to this time, no failure is known back to the ES relay coil and magnet kit replacement that occurred in 1985. Crystal River also uses Clark PM relays in their ESAS. They report no increased failure rate in their Engineered Safeguards Actuation System, but have seen some Clark relay failures in their Remote Shutdown system.

VIII. Identification of Root Cause

"Inadequate preventative maintenance" was determined to be the root cause of the recurring ESAS relay failures in that the frictional buildup from the gradual wear of moving parts and loosening of screws went uncorrected. This condition caused the moving components of the contact and actuator sections of the relay to occasionally bind while re-positioning to an energized state. There is no preventative maintenance task to check the tightness of mounting screws, look for misalignment or to replace old, but functional, contacts.

GPUN has identified an increased friction of the Magnet and Rod assembly, (piece #42) due to loose screws that mount the stationary magnet (piece #43) to the mounting plate. In addition, GPUN identified that increased friction of the relay contacts due to age related wear, and possible misalignment of the bottom-most two relay contacts as contributing to the increased force that relay coils must overcome.

An additional contributing cause is related to the design of the undercut region of the bracket and rod assembly. This will be investigated as a way to further improve system performance.

GPUN identified that the relays with the highest failure rate are those with 14 contacts. The larger the number of contacts, the greater the force required to reposition the relay when re-energizing. Since relays at most other plants have fewer contacts, this observation is consistent with the lack of similar failures elsewhere in the industry.

A root cause investigation in 1998 focused on the magnet kit and coil assembly since these were the parts that were replaced in 1995. No evidence of manufacturing defects was found that would contribute to overheating. Another root cause evaluation of the relay failures was performed in June, 1999 by a multidisciplinary team. The investigation team applied change and fault tree analysis techniques to this recurring problem. Additionally, Southwest Research Institute (SRI) of San Antonio, Texas, performed a root cause evaluation on several examples of relays, of various vintages, including a complete relay that exhibited signs of sticking and overheating from the TMI-1 ESAS system.

The results of the SRI report, confirmed the conclusions reacheo by the recent root cause evaluation that the cause of the relay failures was related to occasional binding as a result of the previously unrecognized gradual wear and degradation of the moving parts. Although the coil and magnetic kits were ali proactively changed out in 1995, most of the parts in the relay contact section are original equipment.

IX. Corrective Actions

A. Immediate and Short Term Actions

The following actions are complete

- All overheated relay coils have been replaced in a timely manner.
- System Engineering began walking down ESAS relays following ES testing in 1998 to look for overheating relays. These checks were formalized by procedure changes to observe for overheating relays.
- The System was placed in Maintenance Rule a(1).
- A Materials Non-Conformance Report was initiated which addressed system operability when taking into account the increased relay failure rate.
- The commercial grade dedication test of the ESAS relay coils was revised for a pickup voltage of 96 VAC as recommended by the manufacturer.
- Operators are aware of these failures and have been provided guidance to manually assist relays, if necessary.

B. Long Term Actions

Engineering has established a long-term plan that addresses both the need to replace degraded relays as well as enhanced maintenance activities to improve relay performance.

- Approximately 64 relays, including all 14-contact relays are planned to be replaced in 13R. Any spare, unused pairs of contacts on these replacement relays will be removed.
- All relays will be inspected and have the screws that mount the core piece to the mounting plate tightened in 13R.

LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Three Mile Island, Unit 1	05000289	99	-- 007 --	1	10 OF 10

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- **A task for maintenance to periodically inspect these relays for screw tightness will be initiated by January 2000.**
- Continue interim checks of relays to verify re-energization of relays **following surveillances that de-energize them.**
- Monitoring per the Maintenance Rule.

*The Energy Industry Identification System (EIIS), System Identification (SI) and Component Function Identification (CFI) Codes are included in brackets, [SI/CFI] where applicable, as required by 10 CFR 50.73 (b)(2)(ii)(F).