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ENGINEERING - TECHNICAL INVESTIGATION REPORT

Temperature Excursion on [REDACTED] Facility [REDACTED]

Technical Investigation Report Number: [REDACTED] REP/FDA/102

AE Date: 15/10/09	AE/Defect Form Ref No: 09514339	Investigation Start Date: 21/10/09
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1. Incident/Defect Summary

The following observation was recorded in Assurance Event Report No: 9514339:
A temperature excursion on [REDACTED] furnace C was experienced. The furnace power was turned down and the FEC was contacted immediately. The lab was restricted and all relevant parties were made aware.

Further data relevant to this investigation:

- The furnace controller set-point was [REDACTED] – to achieve [REDACTED] at the furnace.
- Over temperature Policeman set at [REDACTED]
- The instrumentation for the furnace recorded temperatures in the order of [REDACTED] deg C.
- The furnace temperature controller failed to control the furnace at the correct temperature.
- The Policeman controller circuit failed to shut the furnace down when it exceeded [REDACTED] deg C.

2. Technical Investigation Findings

Scope of investigation

The scope of this investigation is limited to identifying the probable cause of the temperature excursion on furnace C. A separate investigation report [REDACTED] F-SRI/09514339 is being prepared to investigate human factors, maintenance regimes, adequacy of design and any Periodic Review of Safety shortfalls.

Description of furnace temperature control (Refer to Annex A)

There are three furnaces located in [REDACTED]. While this investigation concerns only the C furnace, the control system is similar for each furnace. The basic functional logic is as follows:

A 25 amp three phase contactor that is interlocked through the Process Alarm Annunciator Panel (PAAP) provides power for all three furnaces. The C furnace heater is connected to a single phase of this 240 volt ac three phase supply via Control Relay 13 (contact pair 5 & 9), and a MCB rated at 6 amps.

Contact pair 5 & 9 are normally open and require the coil of Relay 13 to be energised if they are to close allowing power to the heater element. The coil of Relay 13 is supplied with 24 volts via a Eurotherm 818 Controller which is connected to a thermocouple to provide temperature control to the furnace. This 24 volt supply can also be interrupted by a series of interlocks which include Relay 1 (contacts 1 & 3), Relay 4 (contacts 12 & 8) and [REDACTED] restraints.

Relay 1 is controlled via the [REDACTED] controller for the guard [REDACTED]. Insufficient [REDACTED] will de-energise Relay 1 opening contacts 1 & 3 to interrupt the 24 volt supply. Relay 4 is controlled via the Eurotherm Controller 106C acting as the Policeman, which will, on over temperature de-energise Relay 4 opening contacts 8 & 12 to interrupt the 24 volt supply. It will also cause an audible alarm to sound in the PAAP.

If contacts 5 & 9 fail to open on de-energisation of the coil heat to the furnace would be continuous.

None of the above circuits or components had safety system status and thus no EMIT Plan coverage.



Investigation results

This investigation has been carried out in two parts. During the first stage the furnace was electrically isolated. An Interim Technical Investigation Report [REDACTED] REP/FDA/100 was issued which covered this stage. The following was concluded at that stage:

- MCB 6 found to be tripped. This would have removed the electrical power from the heating element resulting in the furnace temperature dropping. Bay [REDACTED] staff stated they had not manually tripped MCB 6.
- Relay 13 labelled as Relay 11 (Relay 11 originally carried out the same function in the A furnace which is stripped down and not in use) suggesting the relay had been swapped over at an earlier date.
- On inspection of Relay 13 its transparent cover was found to be blackened and carbonised around the area of the contacts. This is indicative of contact arcing and wear. (See Annex B Photograph 1)
- Although contacts 5 & 9 on Relay 13 were found as being open when the relay was tested the contacts may have temporarily fused shut and released when the relay was removed for testing.
- Relay 13 which controls the heater appears to be a single point of failure. If contacts 5 & 9 fail to open on de-energisation of the coil, heat to the furnace would be continuous.

Following removal of [REDACTED] disconnection of electrical power to [REDACTED] furnace heating elements, permission was given to undertake a second stage investigation. This followed the following approach:

- Relay 13 was replaced, all [REDACTED] restraints were fitted.
- The guard vacuum was set at the appropriate value, approx [REDACTED].
- Heat was demanded from the Eurotherm 818 controller (set to [REDACTED] initially).
- Relay 13 contacts 5 & 9 closed. The output voltage to the heater was measured on the terminal rail of the Power Distribution Unit (PDU) and a voltage of 240v ac was measured.
- The thermocouple input to the Policeman controller was taken out to simulate a broken t/c (and high temp) and Relay 13 de-energised and switched the heater supply off as expected.
- The input to the policeman controller was then replaced with a temperature simulator and the settings of the policeman controller checked at [REDACTED]. In each case Relay 13 de-energised and switched the heater supply off.
- During all the above testing the operation of the policeman over temperature function activated the audible over temperature alarm.
- The Policeman controller was reset to [REDACTED] and the function of each IGR was tested in turn. In all cases Relay 13 de-energised and switched the heater supply off.
- The controlling Eurotherm was set at [REDACTED] and the temperature input was simulated across the range [REDACTED]. When the simulated furnace temp reached about [REDACTED] Relay 13 de-energised and switched the heater supply off. The same procedure was repeated over a range of set points against input temperatures and the Relay 13 responded as expected.
- Relay 13 was taken out and replaced with a shorting link on pins 5 & 9 to simulate the relay contacts remaining closed.
- The [REDACTED] restraints were removed in turn and the heater output voltage remained on.
- The input to the Policeman thermocouple was raised above the cut off level, again there was no interruption to the heater output voltage.

During none of the above tests did the 25 amp contactor drop out. As details for the operation of Relay 17 were not clearly defined in the available circuit diagrams, it was physically removed to establish its effect. The 25 amp contactor still did not drop out. After consultation with the Lead Investigator it was decided that further investigations of the functional intent and operational logic of the 25 amp contactor would be continued as part of a later review of safety interlocks.

The casing from the original Relay 13 taken from furnace C was removed. It was observed that on the normally open contact the metal pad had completely been eroded and deposited on the common contact. The state of the contacts and relay casing confirm that arcing had taken place between the contacts. As the contacts deteriorate there is a high possibility of their correct operation becoming impaired leading to temporary fusing of them. (See Annex B Photograph 2)

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Configuration Check

The record drawings for this process were found to be incomplete with missing details for control interlocks. They were difficult to interpret with frequent, hard to trace links between drawings. This has hampered the investigation but was not part of the incident cause.

AMS Check

There is no maintenance scheduled for the process equipment or safety systems. There were no formally identified safety systems and no requirement from the facility EMIT Plan to conduct safety system maintenance on this workstation process.

Further actions required

Even if no modification work to rectify short-falls was planned, both the B furnace heater relay and the relay used for this investigation show signs of blackening on their cases and would require replacement prior to a return to service.

- The furnace liner has not been inspected and this would be required prior to a return to service.
- The C furnace element has been tested by using a Megger and comparing its value with furnace B element. The readings between the A & B elements were similar. The element has not been inspected and may require replacement or further testing prior to return to service.
- The trip value of the 6 amp MCB has not been tested.
- Relay 17 had no control function in relation to the 25 amp contactor contrary to available circuit diagrams. Interlocks to the contactor must be confirmed and tested prior to a return to service.

Note: This process/ [REDACTED] is now the subject of a PRS Category 1 shortfall. This identifies technical/engineering corrective actions that need to be undertaken before a return to service. This plan includes provision of [REDACTED] interlocking, an integrity review of the over-temperature protection system and addition of the overprotection system (current and future) onto the facility EMIT Plan.

3. Conclusions

There is no separate control path between the furnace temperature control and furnace over temperature protection. After replacement of Relay 13 all control systems operated as designed. On the removed Relay 13, contact pair 5 & 9 are significantly eroded away. A failure of Relay 13, contacts 5 & 9 to open when the coil is de-energised will cause the furnace heating element to be continually supplied with power. Relay 13 is a single point of failure with IGR's, Guard [REDACTED] Policeman Thermocouple and Temperature Control all using the same contact pair (5 & 9).

No functioning interlocks were determined for the 25 amp contactor. A technical review of the control systems must be undertaken to determine if the control systems and safety systems are suitable and sufficient prior to a return to service ahead of the Category 1 shortfall being fixed.

4. Causes

Direct: Component failure of Relay 13 leading to the furnace heating element being continually energised.

Underlying: Furnace temperature control, Policeman over- temperature, Interlocked [REDACTED] Restraints and [REDACTED] Guard Interlock all have relay 13 contact pair 5 & 9 as a single point of failure.

Underlying: No independent interruption interlock via the 25 amp contactor existing.

Underlying: No Maintenance Plan existing for this process.

5. Human Factors

Not covered in this report.

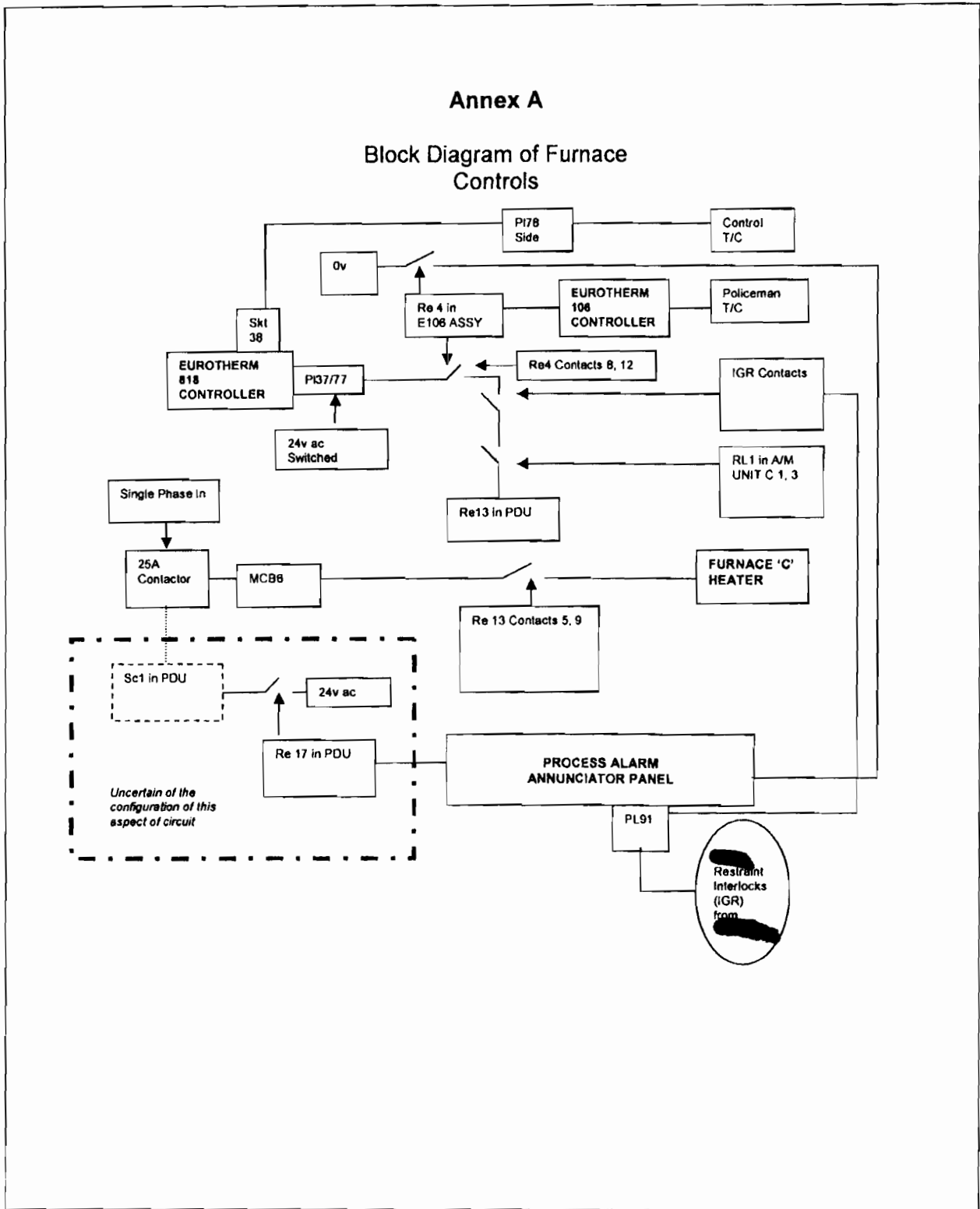
6. Deficiencies and Agreed Actions (Including responsibility and timescales)

There are short falls within the maintenance regime and the process design. No timescales have been currently set. The process may not be returned to service until the PRS Category 1 shortfalls have been addressed.

7. Documents seen, references etc

AE 9514339
Plant Manuals ref [redacted].1/1230310
HR/1/981537
HR/1/981587
HR/1/981571
PRS Shortfall Action Plan [redacted]/PRS/C1/AP/11

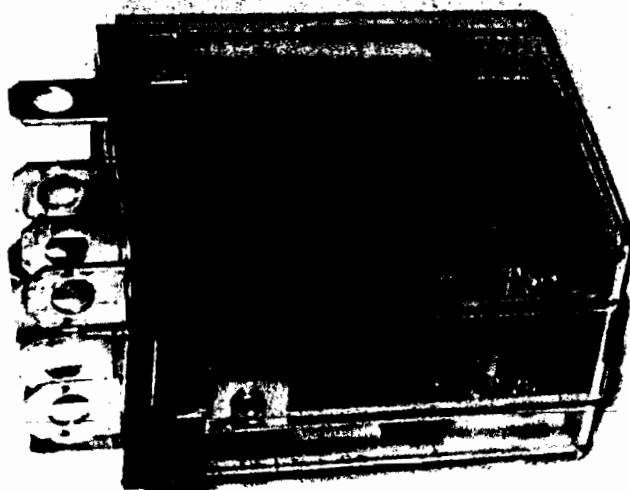
Investigator: [redacted]	Signature [redacted]	Date 18/2/10
Reviewer: [redacted]	Signature [redacted]	Date 16/02/10
Approver: [redacted]	Signature [redacted]	Date 17/2/10



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Annex B

Photograph 1 of Relay 13



Photograph 2 of Relay 13



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