THE PUBLIC SERVICE COMMISSION OF THE STATE OF MISSOURI

Staff Final Electric Incident Report

Kansas City Power & Light Company
Case No. ES-99-581

Hawthorn Station
Boiler No. 5 Explosion
Kansas City, Missouri
February 17, 1999

Operations Division...Electric Department...Engineering Section

Jefferson City, Missouri
January 25, 2001

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SYNOPSIS

Boiler No. 5 at Kansas City Power and Light Company's (KCPL) Hawthorn Generating Station was destroyed in an explosion during the early morning hours on February 17, 1999. The explosion occurred when natural gas entered the off-line boiler and was ignited. Natural gas entered the boiler **due to the burner management system incorrectly sending a signal to open the main gas trip valve and one of the main gas burner valves. The likely source of the ignition spark is believed to be the boiler gas ignitors, which operated because the burner management system incorrectly sent a signal to energize the two gas ignitors.** KCPL's own investigation determined **that the burner management system failed to prevent natural gas from entering the off-line boiler because of several actions taken by KCPL personnel that they apparently believed to be proper at the time they were repairing the burner management system.**

Boiler No. 5 at the Hawthorn Plant was taken off line **at 1:55 p.m. on February 16, 1999,** to complete repair of a leak on a line to a feedwater heater. **At 3:00 p.m. on February 16, 1999, the toilets in the restrooms located in the control room for Hawthorn Unit #5 overflowed into the control room area. Waste water from the toilets ran down two floor levels through existing cable openings where it entered the burner management system control cabinets.

Repairs were initiated by KCPL personnel to clean and dry out the electronic control cards in the burner management system (BMS). While completing this process, the position of two electronic addressing cards were switched in the burner management system. Switching the addressing cards without configuring them properly caused one main gas burner valve to open, and two ignitors to operate. In addition, switching the cards without reconfiguring sent a signal to the main gas trip valve to open.

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The water overflow also caused a solenoid coil monitor (SCM) device for the direct current hard-wired trip (DC-HWT) latching relay in the burner management system to fail by shorting it out. KCPL personnel were in the process of repairing this SCM device when the explosion occurred. The failure of this SCM device prevented the DC-HWT latching relay from re-latching and sending a signal to close the main gas trip valve, which shuts off all natural gas to the boiler. When the master fuel trip relay (MFT), which controls the DC-HWT relay, was manually reset during the repair and check-out of the burner management system, the main gas trip valve received no signal to close, because of the SCM failure, and therefore opened, allowing gas to flow into the boiler.

The result of these actions created a path for gas to enter the boiler, and, at the same time, provided an ignition source. The overall result was to allow natural gas to build up in the boiler and to ignite, resulting in an explosion that destroyed Hawthorn Boiler #5.**

The resultant damage to Hawthorn Boiler #5 was extensive. KCPL made the decision to replace the boiler and hired a scrap contractor, Spiritas Wrecking Company of St. Louis, to remove the damaged boiler. Construction of a new boiler started in December 1999 and the boiler is scheduled for completion in June 2001. KCPL estimates the cost of the new boiler to be **$364.6 million.** The cost to KCPL for the demolition of the debris was **$3.9 million.** As of December 2000, KCPL estimates the cost of the investigation to be **$842,400.** As of December 2000, KCPL estimates the cost of replacement power from February 1999 through December 2000, to be between **$130 million** and **$150 million.**

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Purpose

The scope of Staff's investigation is to report the events that led to the explosion of the Hawthorn Boiler #5, and to make recommendations that would reduce the risk and to try to eliminate the possibility that this type of explosion may recur. The investigation was not designed to determine the issue of negligence or prudence with respect to the actions of any party.

Staff Investigation

At the direction of the Assistant Manager, Electric Department, four (4) members of the Electric Department Staff were sent to investigate the incident on February 26, 1999. At that time, KCPL plant personnel were continuing their efforts to secure the area and determine the extent of the damage. KCPL's preliminary investigation of the incident had begun.

Company personnel provided preliminary information on the events of the incident and Staff personnel inspected the damaged boiler, and the progress of the clean up. The Staff took photographs of the destroyed boiler and surrounding areas.

The Staff made follow-up visits to the site on April 5, 1999, May 6, 1999, June 5, 1999, June 29, 1999, July 21, 1999, August 18, 1999, October 4, 1999, January 11, 2000, and September 6, 2000. Staff visited the site on May 6, 1999, to witness the downloading of the control room data acquisition system.

From August 27, 1999, through December 5, 2000, Staff sent 139 data requests concerning this incident to KCPL. All requests for information were answered.

Extensive time has been required for KCPL and Crawford Investigating Services, KCPL's insurance company's investigation team, to fully investigate this incident, and Crawford's investigation continues at this time. Thus, the Staff filed three interim incident reports to update the Commission during this lengthy process. These interim reports were filed on October 8, 1999, February 4, 2000, and June 6, 2000.

Staff received a written preliminary report on the incident from KCPL on October 2, 2000. The Staff reviewed the KCPL preliminary report and met with KCPL personnel on November 15, 2000, to discuss KCPL's preliminary report. Staff also participated in conference calls with KCPL personnel on November 28, 2000, December 7, 2000, December 14, 2000, to discuss KCPL's preliminary report.

Staff received a final written report on the incident from KCPL on December 18, 2000. A copy is attached in Appendix E. The Staff's report is an evaluation of KCPL's report and relies heavily on the investigation and conclusions contained in the final KCPL report.

A final report from Crawford Investigating Services is not yet available to KCPL, and there is no estimated date when it will be available. The report from Crawford may include conclusions and discoveries not in the KCPL report, and is therefore, not covered by this report.

As part of the Staff's investigation into the Hawthorn #5 Boiler explosion, the Staff reviewed the Hawthorn Station safety and operating procedures, in place prior to the explosion, including the equipment tagging-out procedures, and the boiler operation procedures. Staff determined that no KCPL employees deviated substantially from KCPL safety procedures or operating procedures. Although, based upon the information of which the Staff is presently aware of, KCPL's safety and operating procedures in place prior to the explosion were adequate, **the Staff is now recommending modifications to KCPL's operating procedures as a result of what Staff learned about the BMS from its investigation.**

Facility Description

The Hawthorn Station, prior to the time of the explosion, consisted of a steam boiler and a turbine-generator identified as Unit #5, and one combustion turbine identified as Unit #6. The plant is owned and operated by KCPL, of Kansas City, Missouri. The plant is located near the Missouri River in Kansas City, Missouri (see photograph 1 in Appendix A).

Unit #6 began commercial operation in July of 1999, and is a Siemens 140 MW combustion turbine burning natural gas. Unit #6 is located outside of the main plant building and southeast of the Unit #5 area.

Unit #5 began commercial operation in May of 1969. Hawthorn Unit #5 consisted of a Combustion Engineering boiler currently burning low sulfur, low BTU western coal, with natural gas to produce high pressure steam at 1005 degrees F and 2400 psig **(see Figure 1-1 in Appendix B)** for powering a General Electric turbine generator with net capacity of 476 megawatts (MW). Unit #5 capacity comprised approximately **14%** of KCPL's total generating capacity.

The Hawthorn Boiler #5 was a drum-type boiler, with tangential burners. A large drum, located at the top of the boiler, supplies water to the wall tubes of the boiler, and also acts as a collection point for the steam produced. The boiler water walls, made of vertical tubes welded side-by-side, form a vertical rectangular box that surrounds the area of the boiler called the furnace. The furnace area is where the fuel and air mixture from the burners located in the corners is ignited creating the fire zone area. In this area, the vertical water wall tubes absorb heat from the fire and boil the water, producing steam, which is collected in the steam drum.

Typically utility boilers are designed with a safety/protection system, which trips or shutdowns all fuel when a boiler trips offline for any reason. This system is also designed to prevent an improper boiler startup, where residual unburned fuel, that is already in the boiler, could be ignited, or where fuel could be introduced into the furnace without ignition. This system is usually referred to as the Burner Management System (BMS). The BMS basic design is a series of relays[1] and latching relays (interlocks) that interlock with gas valves, ignitors, coal pulverizers, coal feeders, fans, and boiler control instrumentation to insure no fuel gets into the boiler at the wrong time. With the advent of computer control systems a BMS sometimes incorporates computer logic in the design of the interlocks. Details of the function of a typical burner management system and a glossary of terms are in Appendix C.

The original BMS on Hawthorn Boiler #5 had been replaced in **1995** with a Programmable Logic Controller (PLC) based system with latching relays. KCPL hired engineering consultants to procure, design and install the new BMS. **The new BMS consisted of a screen in the control room on the third floor elevation, and control cabinets located on the first floor elevation below the control room.**

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1 A relay is a device that acts like a switch. Most relays are made up of two parts: a solenoid coil and contacts. When an electrical current is applied to a solenoid coil, the plunger, or core, inside the coil moves. Attached to this plunger are contacts, so when the plunger moves, the contacts change positions. A simple relay has two conditions, usually referred to as "energized" and "de-energized". A relay can have two types of contacts, usually referred to as "normally open" and "normally closed" in the de-energized condition. So when a relay in a de-energized condition with a normally open contact is energized the normally open contact will close. When this relay is de-energized, the contact will open.

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Timeline of the Events Leading up to the Explosion

**02/13/99	00:05	KCPL personnel bring Hawthorn Unit #5 off line to repair a boiler tube leak.
02/14/99	17:30	KCPL personnel tag No. 4 feedwater heater out of service for the repair of a leak in a line to the shell.
02/16/99	01:00	Boiler #5 tube leak repair is complete and KCPL personnel release the boiler for service.
02/16/99	03:38	KCPL personnel, as per normal procedures establish a fire in Boiler #5 for operation.
02/16/99	07:15	KCPL shift foreman notifies KCPL maintenance personnel of toilet problems in the restrooms located in Unit #5 control room area on the third floor level. KCPL personnel call the Reddi-Rooter serviceman.
02/16/99	09:37	Reddi-Rooter serviceman arrives at plant.
02/16/99	09:45	Reddi-Rooter serviceman works in the Unit #5 control room restroom.
02/16/99	11:45	Reddi-Rooter serviceman moves to the sewer pipe cleanout on the first floor.
02/16/99	11:55	Boiler #5 startup is aborted. KCPL determines the work on feedwater heater must be completed before turbine can be put on line.

02/16/99	13:00	Reddi-Rooter serviceman's jetting tool gets stuck in the sewer piping.
02/16/99	13:55	Boiler #5 burners are shutoff by KCPL.
02/16/99	14:00	Reddi-Rooter serviceman notifies the KCPL control room operators that the jetting tool is stuck in a check valve. He requests sewer line drawings.
02/16/99	14:30-15:00	Pump in sewage lift station #1 starts. Water overflows the toilets in the control room restroom. KCPL personnel discover water flowing into the BMS control cabinet on the first floor.
02/16/99	14:53:44	Control room alarm log printout: Fuel Safety System AC Lost.
02/16/99	14:53:47	Control room alarm log printout: Fuel Safety System AC Lost - Reset. Alarm reset without operator intervention.
02/16/99	15:00	Unit #5 control room toilets stop overflowing.
02/16/99	15:05:27	Control room alarm log printout: Fuel Safety System DC Lost.
02/16/99	15:05:32	Control room alarm log printout: Fuel Safety System DC Lost - Reset. Alarm reset without operator intervention.
02/16/99	15:22	KCPL maintenance personnel request control room operator to initiate a master fuel trip (MFT) reset. Control room operator initiates a manual reset, which clears alarms and unlatches the HWT relays, by pressing the reset button on control panel.

02/16/99	15:22:20	KCPL personnel power down the BMS Programmable Logic Controller (PLC) racks #1 & #2. AC breaker found tripped. Control room alarm log printout: MFT Tripped - Reset. Alarm reset without operator intervention.
02/16/99	15:25:54	Control room alarm log printout: Furnace Pressure High or Low.
02/16/99	15:25:55	Control room alarm log printout: Furnace Draft Transmitter Anomaly.
02/16/99	15:25:57	Control room alarm log printout: Furnace Pressure High.
02/16/99	15:26:01	Control room alarm log printout: Air Flow Less Than Minimum.
02/16/99	15:26:02	Control room alarm log printout: FD/ID Fan Directional Block Actuated.
02/16/99	15:26:58	Control room alarm log printout: FD/ID Fan Directional Block Actuated - Reset. Alarm reset without operator intervention.
02/16/99	15:26:29	Control room alarm log printout: Furnace Pressure High or Low - Reset. Alarm reset without operator intervention.
02/16/99	15:27:00	Control room alarm log printout: Furnace Draft Transmitter Anomaly - Reset. Alarm reset without operator intervention.
02/16/99	15:27:00	Control room alarm log printout: Furnace Pressure High- Reset. Alarm reset without operator intervention.

02/16/99	15:30 to 16:00	KCPL maintenance personnel begin cleanup and repair of the BMS. Input/output cards pulled from rack #1 to clean.
02/16/99	16:00 to 16:30	KCPL personnel open the breakers to lift station #1 pumps to prevent the pumps from operating again.
02/16/99	17:00 to 17:30	KCPL personnel locate the check valve and remove the cover. Reddi-Rooter jetting tool found in check valve and removed.
02/16/99	17:50	Reddi-Rooter serviceman leaves plant.
02/16/99	19:20	KCPL personnel clean and power up Rack #1 of the PLC. No fault indicated. Tripped AC breaker traced to SCM3. Alarm printout: MFT Tripped.
02/16/99	21:00 to 21:25	KCPL personnel pull input/output cards from rack #2 to clean. Fault indication on ASB card. ASB card in rack replaced with new ASB card. Fault still indicated.
02/16/99	21:25	KCPL personnel power down rack #1 and #2. ASB cards switched from rack #1 and rack #2; both racks powered up. Fault indication still shown on rack #2. Alarm printout: MFT Tripped - Reset.
02/16/99	21:30	KCPL personnel power down rack #2 of the PLC. KCPL maintenance personnel take a dinner break.

02/16/99	22:08	KCPL maintenance personnel resume work on rack #2. Rack #2 powered up and down approximately six times as each card is removed and cleaned.
02/16/99	23:00 to 23:30	Rack #2 powered up. No faults indicated. KCPL personnel resume work on repairs to SCM3.
02/17/00	00:28	Boiler explodes.**

Discussion of events leading up to the explosion

**On the afternoon of February 14, 1999, during the outage to repair the boiler tube leak, KCPL personnel made the decision to repair a hole in a line to the shell of the No. 4 feedwater heater located on the turbine deck elevation. The No. 4 feedwater heater was then tagged out of service for Thermo Engineering Inc. to initiate the repair work. Later that day, KCPL personnel believed that the repairs to the line to the shell of No.4 feedwater heater could be continued and be completed while the boiler was brought back on line, so after the boiler tube leak was repaired, the boiler was released for operation.

Early on February 16, 1999, following standard start-up procedures, a fire was established in Hawthorn Boiler #5, as the welding contractor, Thermo Engineering Inc., continued the repair work on the No. 4 feedwater heater.

Later that morning, while the feedwater heater was being repaired and the boiler was being brought on-line, the KCPL shift foreman notified the Hawthorn Plant maintenance personnel that the toilets were not flushing properly in the restrooms located in the Unit #5 control room area on the third floor (see photographs 2, 3, 4 in Appendix A). Reddi-Rooter, the KCPL sewer line contractor, was called and arrived at the plant later that morning. The Reddi-Rooter serviceman began his attempt to clear the waste water line at the Unit #5 control room restroom. Unable to correct the toilet problem, the Reddi-Rooter serviceman moved down to the first floor and began using a jetting tool in a sewer system pipe cleanout.

At noon, the Unit #5 startup was aborted because of excessive air leakage into the turbine condenser. KCPL personnel determined that the excessive air leaking into the condenser was coming through the hole in the shell of No. 4 feedwater heater. This excessive air leakage into the condenser prevented a vacuum from being created and, therefore, prevented rolling the turbine for startup. Without the turbine available for operation, there was no need for steam from the boiler, so KCPL operating personnel started the boiler shutdown procedures.

During this time, the Reddi-Rooter serviceman got the jetting tool stuck in the check valve preventing the valve, from closing properly. The check valve allows water flow in only one direction and is used in the Hawthorn Station waste water system to prevent the waste water from the pressurized waste water section of piping from backing up into the un-pressurized waste water section of piping. The Reddi-Rooter serviceman notified the Unit #5 control room that the jetting tool was caught in the check valve, and requested drawings of the sewer system to determine the exact location of the check valve.

While the check valve was blocked open by the jetting tool, one of the two pumps in the # 1 waste water lift station was started automatically by the high level float control in the sump. When the level of the waste water reached a predetermined high level in the sump, the float closed a switch contact and one of the pumps started. When the level of the waste water in the sump reached a predetermined low level in the sump, the float opens a switch contact and the pump stopped.

Waste water from the #1 waste water lift station backed up through the blocked open check valve and into the Unit #5 control room restroom toilets, and overflowed onto the floor. Water ran out into the control room and down the openings located in the floor specifically for the control cables (see photograph 5 in Appendix A; see tab 4 of KCPL's report in Appendix E). The water flowed down from the third floor control room to the second floor where there are other openings in that floor (see photographs 6,7and 8 in Appendix A; see tab 5 of KCPL's report in Appendix E). Water then flowed down to the first floor where the BMS control cabinets are located (see photographs 9, and 10 in Appendix A; see tab 6 in KCPL's report in Appendix E). Although it is unknown exactly how much waste water flowed through the system, the Staff estimates less than 700 gallons flowed into the control room (see Appendix D).

The BMS control cabinets contained wiring, terminal strips, relays, solenoid coil monitoring (SCM) devices, and the PLC racks which contain electronic control cards (see photographs 11, and 12 in Appendix A). Water got into racks #1 and #2 of the PLC and the BMS began giving alarms, and fault indications. The water also tripped an AC circuit breaker and shorted out the SCM-3 device located in the BMS cabinets (see figure 1-2 in Appendix B). The water overflow stopped at approximately 3:00 p.m. on February 16, 1999.

When water entered the BMS, several alarms were indicated in the Unit #5 control room. KCPL maintenance personnel requested the control room operating personnel initiate a reset of the MFT in an attempt to clear the alarms.

By 4:00 p.m., KCPL maintenance personnel had started to clean the electronic cards in racks #1. After initial cleaning, rack #1 showed no fault indication. KCPL personnel then began cleaning the cards in rack #2, but rack #2 continued to show a fault indication. The KCPL maintenance personnel changed out a module and a communication addressing card in rack #2.**

At 00:28 on February 17, 1999, Boiler #5 exploded. **Operators observed a natural gas flame shooting out of the debris of the boiler. One operator ran to the manual gas shut-off valve located near the Williams pipeline metering station and closed it, which caused the fire to die out.**

Kansas City Fire Department personnel as well as Kansas City Police Department personnel arrived and monitored the boiler and plant area for several hours.

Timeline of Events of February 16-17, 1999, and the determination of why the event occurred as discovered by the KCPL Investigation

NOTE: This timeline shows what was determined after the investigation by KCPL to have been the causes of the events shown on the timeline at pp. 7-11. Dates and times relate to the timeline on pp. 7-11.

**02/16/99	07:15	The problem with the toilets in the restroom in the Unit #5 control room area was discovered to be due to a collapsed waste water pipe located in the plant yard just before the waste water #2 lift station (see tabs 15 and 16 of KCPL's report in Appendix E).
02/16/99	15:22	The DC-HWT latching relay of the BMS unlatched, and remained unlatched due to the failure of the SCM3.
02/16/99	15:22:00	Alarm printout: MFT Tripped - Reset. This was determined to be a false indication of an alarm, which was caused when the PLC rack #1 was powered down.
02/16/99	19:20	Alarm printout: MFT Tripped. This was determined to be a false indication of an alarm, which was caused when the PLC rack #1 was powered up.

02/16/99	21:25	Main gas trip valve opened, corner burner gas valve opened, and ignitors are energized. This was determined to be due to the ASB cards being switched. Main gas header pressure was 6.35 psig. Alarm printout: MFT Tripped - Reset. This was determined to be a false indication of an alarm, which was caused when the PLC rack #1 was powered down.
02/16/99	21:30	Ignitors de-energized. This was determined to be due to rack #2 being powered down.
02/16/99	22:08	Main gas header pressure was 3.27 psig. Gas flow for hour ending 22:00 was 145 MCF. A corner burner gas valve opened and one (1) of three (3) gas vent valves opened. Ignitors are energized and de-energized. This was determined to be due to rack #2 being powered up and down while each card was cleaned.
02/16/99	23:00	Gas flow for hour ending 23:00 was 263 MCF.
02/16/99	23:00 to 23:30	Powered up rack #2. No faults indicated. Work resumed on repairs to the SCM3.
02/16/99	23:30	Corner burner gas valve open and ignitors are operating.
02/16/99	24:00	Gas Flow for hour ending 24:00 was 268 MCF.
02/17/00	00:28	Boiler exploded.
02/17/99	01:00	Gas flow for hour ending 01:00 was 314 MCF.**

Details from the KCPL Investigation of the Explosion

After the explosion, KCPL secured the area around the damaged boiler and initiated an air sampling check for asbestos. Pipe insulation in older power plants usually contains asbestos fiber, which has been declared a health hazard, and its removal is regulated by the Environmental Protection Agency (EPA), and the Occupational Safety & Health Administration (OSHA).

KCPL contracted for the removal of the boiler debris, and general cleanup of the site.

An investigation into the cause of the explosion was initiated by KCPL personnel, and shortly after that, KCPL's insurance company hired Crawford Investigating Services (Crawford), which began its investigation of the explosion. KCPL personnel have conducted an investigation into the explosion, and Crawford has conducted its own separate investigation. These investigations have been conducted independently. The Crawford investigation is not available, and Crawford has not given KCPL an availability date for its report.

KCPL's preliminary investigation of the explosion determined that it was a natural gas explosion. **KCPL's investigation team began to attempt to determine how natural gas could have entered the boiler since the existing BMS was designed to prevent that from happening. KCPL's investigation team reviewed the electrical wiring diagrams of the BMS and the logic diagrams of the PLC in an attempt to determine a scenario of how gas could have gotten into the boiler.**

The findings of the KCPL investigation team identified **two specific things that occurred which led to gas being allowed into the boiler. First, the communication addressing cards of the PLC in racks #1 and #2 were switched without being properly configured, and second, a solenoid coil monitoring (SCM3) device shorted out due to the waste water, which removed the closed signal interlock to the main gas trip valve (see tab 3 of KCPL's report in Appendix E). These two events are discussed in detail below.

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PLC Racks

The PLC has the capability to have many input signals and output signals. Each of these input and output signals enter and leave the PLC through computer cards positioned in slots located in racks. External electrical control wires from devices in the plant are connected to a specific card location on the racks. The communication addressing cards are designed to route specific signals from the PLC to a specific card location in the rack, where the signal goes out on the electrical control wire. The communication addressing cards also are designed to route specific signals to the PLC from a specific location in the rack, where the signals come from field devices in the plant. Thus when the PLC software sends a signal to close a valve, that signal is routed by the communication addressing card to the proper rack and to a specific card location, which has the correct hard wired path to the valve (see figure 1-3 in Appendix B).

Because of the fault indication on the ASB card, KCPL personnel apparently believed there was a bad communication addressing card in rack #2, and following the vendor's trouble shooting guide, replaced the existing communication addressing card with a new card. When this failed to clear the fault indication on rack #2, they removed the new card from rack #2 and placed it in rack #1 in an attempt to determine if the new card was functioning properly. Getting no fault indication on rack #1 they left the new card in rack #1, and put the communication addressing card from rack #1 into rack #2, and continued to clean and dry the other cards in rack #2.

The new communication addressing card now in rack #1 was configured for rack #2, and, therefore, was identifying rack #1 to the PLC as rack #2. The

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communication addressing card now in rack #2 was configured for rack #1, and, therefore, was identifying rack #2 to the PLC as rack #1 (see figure 1-4 in Appendix B). KCPL's investigation team has not determined how or when the Dual In-line Package (DIP) switches for the new ASB card were configured for rack #2. The KCPL investigation team also has determined that the information in a particular chart in the vendor trouble-shooting guide on which the KCPL employees relied, did not indicate that the DIP switches on the new ASB card should have been re-configured when used in rack #1 (see tab 14 of KCPL's report in Appendix E).

The PLC was functioning as it was programmed to function and was sending signals to rack #1 and rack #2, but the switched communication addressing cards were redirecting the signals for rack #2 to rack #1, and signals for rack #1 to rack #2. A signal sent by the PLC to rack #2, was actually directed by the communication addressing cards to rack #1. Thus, the signal went to the computer card set up to **partially open the main gas trip valve** (see tab 10 of KCPL's report in Appendix E). Three signals sent by the PLC to rack #1, were actually directed by the communication addressing cards to rack #2, where they went to the computer cards set up to **(a) open the corner burner gas valve, (b) operate two ignitors, and (c) closed one of four vent valves on the natural gas burner piping**.

Latching relays and SCM3 device

The signal to open the main gas trip valve is interlocked through the direct current hard-wired trip (DC-HWT) relay. This interlocking relay is one of three latching relays used in the master fuel trip section of the BMS. A typical relay requires an electrical signal to operate it into the energized position, and the removal of that signal causes the relay to move back into its original or de-energized position. A latching relay[2] requires one electrical signal to operate it into the latched position, and a different electrical signal to operate it back into the unlatched position. Because it requires two separate and distinct signals to latch and unlatch this type of relay, it is used as an interlock device. In this particular BMS, the latched position is used to lock the fuel system in the non-operable mode, and the unlatched position is used to allow the fuel system to be operated.

A design feature of the BMS on Hawthorn #5 Boiler was solenoid coil[3] monitoring (SCM) devices, which would test the solenoid coil of the three latching relays to determine if they would operate (see photograph 13 in Appendix A). To latch the latching relays, an electrical signal from the MFT relay was sent to the SCM device, and then the SCM device sent a signal to the relays to latch. However, the SCM3 for the DC-HWT relay was shorted out from the waste water overflow and, therefore, could not relatch the DC-HWT relay, or keep the relay latched.

The BMS was designed so that the reset button needed to be pushed to clear any alarms before initiating the boiler start up. The button also unlatched the latching relays in the MFT system before any interlocks of the BMS were satisfied. This could be done because the PLC was programmed to relatch all the HWT relays,

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2 **A more sophisticated type of relay is a latching relay. This type of relay usually has two solenoid coils instead of one. In order for the contacts to change from one condition to the other condition and back, each coil must be energized. When one coil is energized the relay will move to the latched position and stay in the latched position until that coil is de-energized and the second coil is energized. The relay then will be unlatched.**

3 **A solenoid coil is wire wrapped around a hollow core containing a metallic plunger. When electric current is applied to the coil of wire the electronic field produced moves the plunger.**

including the DC-HWT relay, if the proper startup conditions were not met. Thus, on a normal startup the operation personnel manually pushed the reset button, which cleared any alarms, and unlatched all the HWT relays, but the PLC then automatically relatched the HWT relays.

On February 16, 1999, when the KCPL operations personnel manually pushed the reset button, the DC-HWT relay unlatched and remained unlatched. With the DC-HWT relay in the unlatched position, the main gas trip valve remained closed but there was no close signal to keep it closed (see figures 1-5, 1-6, and 1-7). Therefore, when a PLC signal was rerouted by the switched ASB cards, the main gas trip valve only had an open signal, and the valve partially opened.

It is not certain at this time, and may never be known, what would have happened if the SCM3 had not failed. At the time the ASB cards were switched, the main gas trip valve would have been receiving two signals, one to open and one to close. The valve would have received a close signal from the DC-HWT relay, as it would not have remained unlatched when the reset button was manually pushed, because the functioning SCM3 would have relatched it. The main gas trip valve would also have received an open signal from the switched ASB cards. Even thought the main gas trip valve was recovered from the February 17, 1999 explosion, without specific knowledge of the main gas trip valve operation and setup, it is not known whether this valve would have remained closed, or would have opened when it received the two conflicting signals.

KCPL's investigation team has concluded that the design of the BMS with no redundancy for the SCM devices was a poor design. The failure of the SCM3 device prevented a latching relay from functioning properly, which was required to trip the main gas trip valve.

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With the main gas trip valve and the corner burner gas valve open, a path was created allowing natural gas into the boiler. KCPL's investigation team believes that the natural gas entering the boiler mixed with the available air and reached the proper proportional mixture of air and natural gas needed for combustion, and was then ignited causing the explosion. Due to the total destruction of the boiler, KCPL's investigation team could not determine the exact source of ignition or spark, however, because the ignitors were operating, KCPL's investigation team presumed that this was the source of ignition.**

Personnel

KCPL informed Staff that there were no OSHA reportable injuries.

At the time of the explosion there were fourteen (14) KCPL employees on site: **six (6) of the KCPL personnel were in the Unit #5 control room; four (4) workers were in the fuel office located by the coal unloading area outside of the main plant building; three (3) workers were in the first floor computer room; and one (1) KCPL employee was in the water laboratory located on the SE corner of the turbine building on the third floor.**

There were also three (3) welding contractor employees on site working to repair the No. 4 feedwater heater. **Two (2) were at the feedwater heater located on the turbine elevation west of the boiler, and one (1) was in the contractor office trailer located north of the boiler building.**

The force of the explosion appeared to go up and not out, and the damage was contained in the immediate area of the boiler and did not propagate into any area where personnel were located **(see tab 7 of KCPL's report in Appendix E).** This allowed workers on the site to escape serious physical injury.

Property Damage

The boiler and the boiler related equipment located in the boiler building, as well as the boiler building itself, were destroyed by the explosion (see photographs 14 and 15 in Appendix A; **see tab 7 of KCPL's report in Appendix E**). The structural steel supporting the boiler and the building walls close to the boiler were damaged beyond repair. The ductwork from the boiler to the precipitators was damaged (see photograph 16 in Appendix A). The coal bunkers and the supporting structural steel were damaged (see photographs 17 and 18 in Appendix A).

Flying debris from the explosion broke windows and damaged siding in the outlying buildings in the area surrounding the boiler building.

Damage Repair

In the immediate days after the incident, KCPL's first priority was to secure the plant area and identify any unstable structures that might fall. A preliminary investigation indicated that the boiler was beyond repair. A contractor was hired to remove the large pile of debris left by the explosion, and to remove the unstable coal bunker, dust collector, and precipitator ductwork (see photographs 19, 20, 21, 22, 23,24, 25, 26 in Appendix A).

KCPL initiated the testing for asbestos, and established procedures for properly containing and removing any asbestos before any work could start.

Removal of the boiler debris was completed by November 1999.

KCPL undertook an investigation into the cost of building a new boiler in the same location and determined it was economically feasible to do so. Construction of a new boiler began in October 1999, with a projected operation in-service date of June 2001 (see photographs 27 and 28 in Appendix A).

Meteorological Data

The National Oceanic and Atmospheric Administration (NOAA) reporting station at Kansas City International Airport located approximately 16 miles northwest of the Hawthorn Station reported an average temperature of 35 degrees Fahrenheit on February 16, 1999. The precipitation recorded was 0.00 inches. The weather reported at Kansas City International Airport is reflective of the weather conditions at Hawthorn Station on the day of the incident. The weather is not considered to have been a factor contributing to the explosion.

Company Notification

Missouri Public Service Commission rule 4 CSR 240-20.080 requires that any forced outage of a generating unit constituting 20% or more of the utility's generation capacity, or which results in property damage in excess of $50,000, be reported by telephone by the end of the first business day following the incident and in writing within five (5) business days. The Staff was notified of the incident by telephone at 8:00 a.m. on Wednesday, February 17, 1999. A FAX of a KCPL news release was received at the Commission on February 17, 1999.

CONCLUSIONS

From the investigation conducted by the Staff of the events surrounding the incident at Hawthorn Plant involving the explosion in the Hawthorn #5 Boiler, the Staff draws the following conclusions:

1. No OSHA reportable injuries resulted from this incident.
2. No Commission rules were violated by KCPL.
3. No KCPL employees deviated substantially from KCPL safety procedures or operating procedures.
4. The boiler and surrounding supporting structure were destroyed. KCPL estimates the cost for a replacement boiler is **$364.6 million.** KCPL estimates as of December 2000, the cost for replacement power is between **$130 million** and **$150 million.** Staff investigation did not make any evaluation of the accuracy of these estimates. The actual cost of this incident including insurance proceeds is a matter that will be considered in KCPL's next rate case.
5. **The damage to Hawthorn #5 Boiler was due to a series of actions taken by KCPL while cleaning and repairing the BMS.**
6. There is no conclusion at this time on the part of the Staff regarding prudence or imprudence or what KCPL knew or should have known about the impact of the actions or non-actions of its personnel, or the effect of an item(s) such as the design of a particular component of the plant.

RECOMMENDATIONS

Based on the Staff's investigation and review of the incident, Staff recommends the Commission direct that:

1. **Kansas City Power & Light Company review and test the fuel trip control logic on all its non-nuclear units and make a determination whether or not there is a possibility that a failure of one device of the control system could put the unit in a hazardous condition. KCPL should produce a report of its findings, including a description of the trip logic for each unit reviewed, and file it in this case.
2. KCPL make the modifications necessary to the control systems of all its non-nuclear units to ensure a safe trip condition of those units. KCPL should produce a report on what modifications were made, and file it in this case.
3. KCPL review the operating procedures of all its non-nuclear units to determine if procedures need to be modified to ensure a save trip condition of those units. KCPL should make such modifications, and report the changes in a filing in this case.
4. KCPL include a requirement in all specifications for future control work that the designer/contractor of any modifications of the control logic on any non-nuclear unit specifically identify the control logic trip sequence. KCPL should include a requirement that all future burner management system designs or modifications be reviewed by knowledgeable persons to determine if it meets the latest revision of the National Fire Protection Association Code and Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boiler-Furnaces, before for any future modifications and or replacement of BMS on any non-nuclear unit.

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5. KCPL should revise procedures or install equipment at all non-nuclear plants to manually isolate any fuel from the boiler while any work is being performed on the burner management system, and/or fuel trip relays.**

6. KCPL file the above reports, and procedural changes in writing with the Commission within six (6) months.

7. The Commission issue an Order requiring KCPL to file a response to this Electric Incident Report in this case within 30 days.

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APPENDIX A

Photographs

List of Photographs

1. An aerial view of Hawthorn Station prior to the explosion. Boiler #5 is highlighted.
2. **A view of the boiler-turbine control panel in the Unit #5 control room.**
3. **A view of one of the restrooms located in the Unit #5 control room.**
4. **A view of the second restroom located in the Unit #5 control room.**
5. **A view of the backside of the boiler-turbine control panel in Unit #5 control room, showing a location of holes in the floor.**
6. **A view of control cabinets and conduit on the second floor.**
7. **A view of control cables on the second floor.**
8. **A view of control cables going through the floor on the second floor elevation.**
9. **A view of the upper part of the BMS control cabinet on the first floor, showing the cables entering the cabinets.**
10. **A view of the upper part of the BMS control cabinet on the first floor showing cables entering the cabinet.**
11. **A view of the BMS control cabinet on the first floor showing relays.**
12. **A view of the BMS control cabinet on the first floor showing relays and the location of the removed SCM devices.**
13. **SCM devices in plastic bags, which have been removed from the BMS control cabinet for examination.**
14. A view of the damaged boiler from the north side looking southward.
15. A view from the east looking westward. An area is indicated where Boiler #5 would have been.
16. A view of the precipitator ductwork damage.
17. A view from the north, looking southward at the coal bunkers leaning toward the turbine room elevation. The coal bunkers were located on the west side of the boiler.
18. A view from the west, looking eastward at the coal bunkers.
19. A view from the north, looking southward at the damaged boiler. Contractor's crane is removing pieces of the boiler debris. The steam drum can be seen in the center of the debris with the piping still attached and bent.
20. A view from the north, looking southward at the damaged boiler. Contractor's crane is removing pieces of the boiler debris.
21. A view of the natural gas piping and valves recovered from the debris.
22. A view of one of the corner burners recovered from the debris.
23. A view from the west, looking eastward at the area where the coal bunkers were located.
24. A view from the north, looking southward at the area where the coal bunkers were located.
25. A view from the northeast, looking southwest at the area where the boiler was located. The structural steel for the coal bunkers is still standing.
26. A view from the east, looking westward at the turbine building. The machine in the area where the boiler was located is removing the original boiler concrete footings.
27. A view from the turbine floor elevation looking eastward at the area where the boiler was located.
28. A view from the turbine floor elevation looking northward at the construction of the new concrete footings for the new boiler.

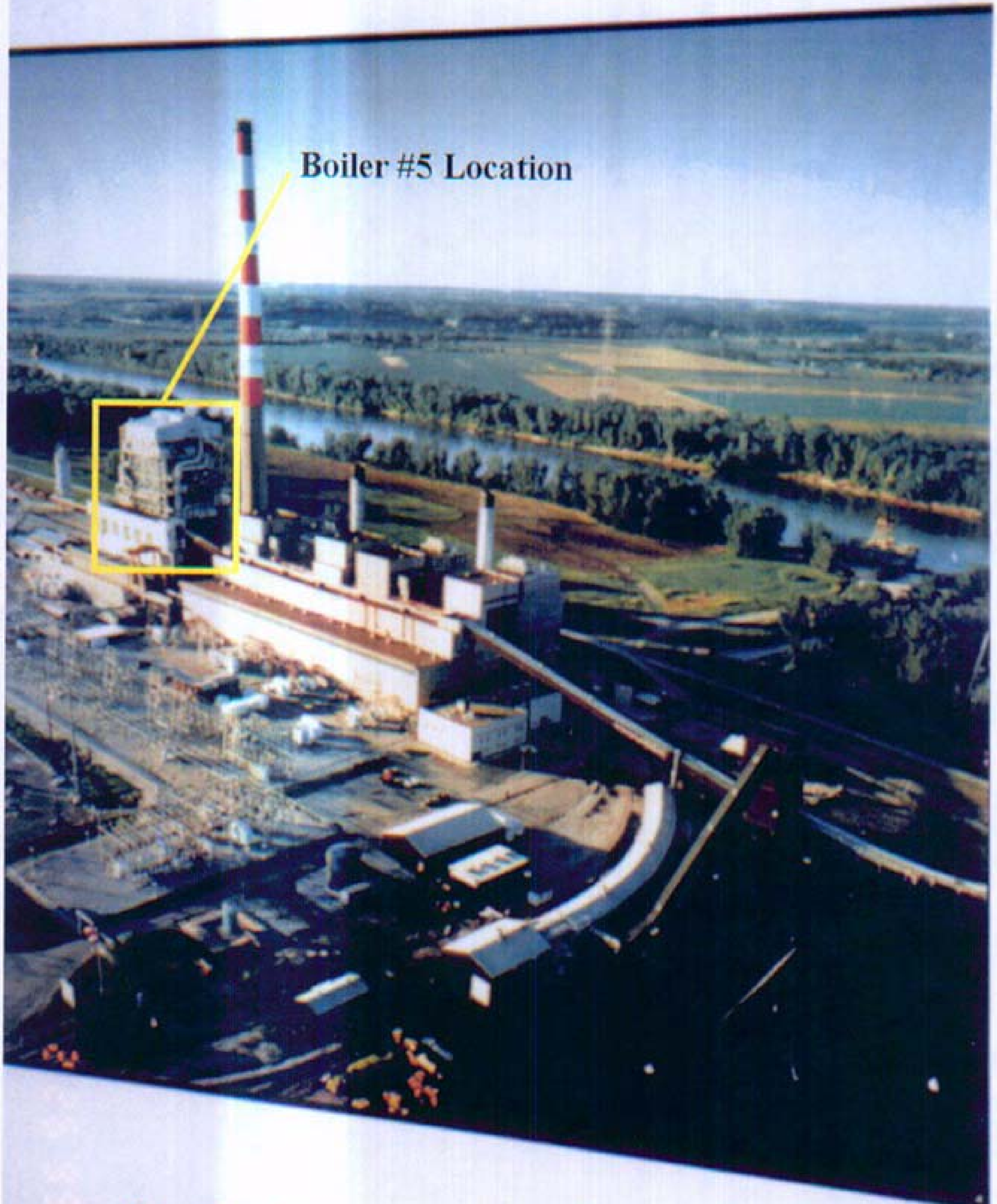

Photo No. 1

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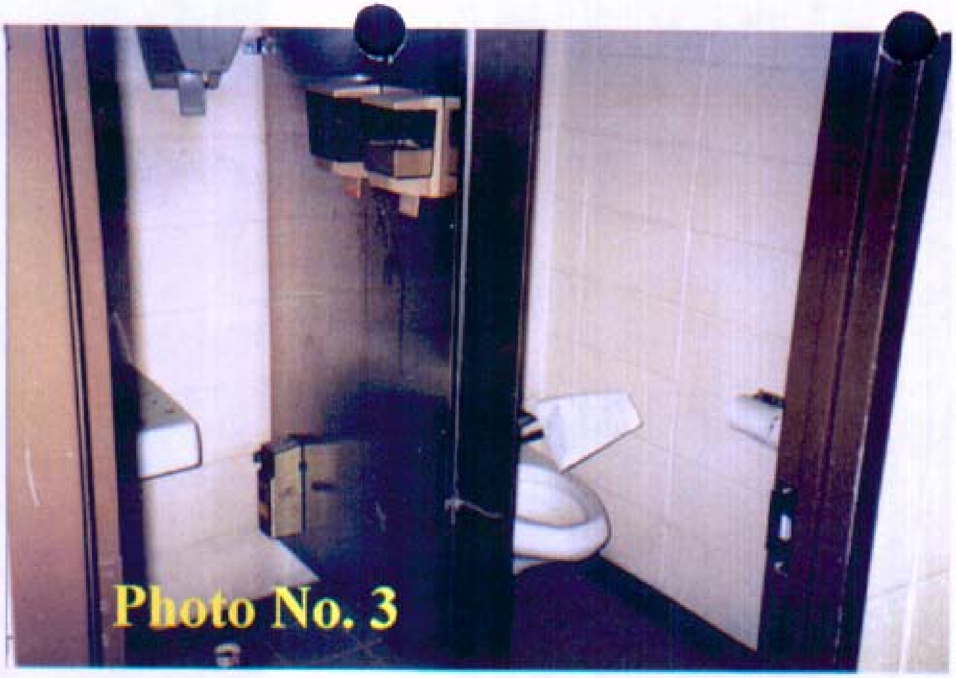
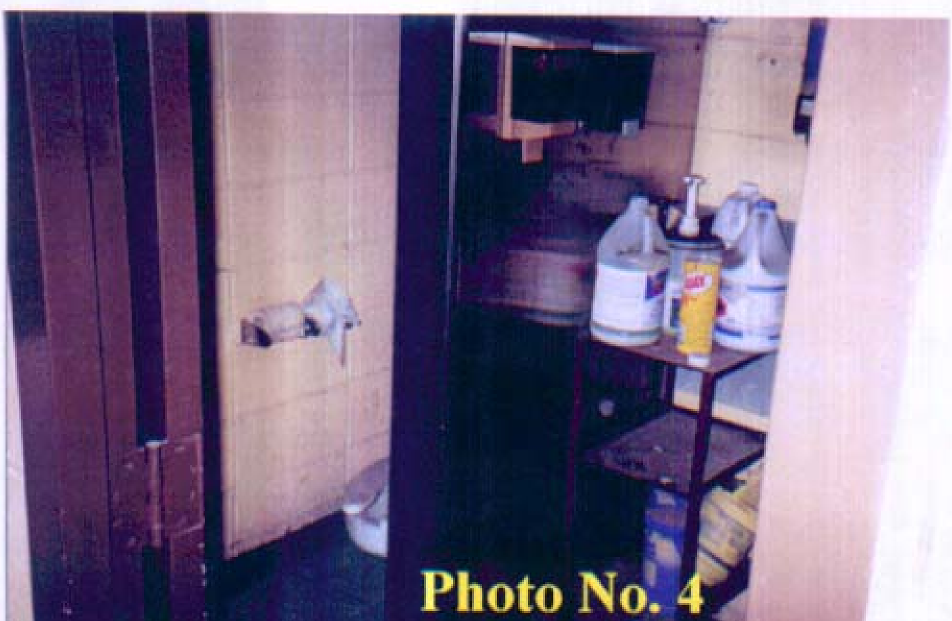


Photo No. 3



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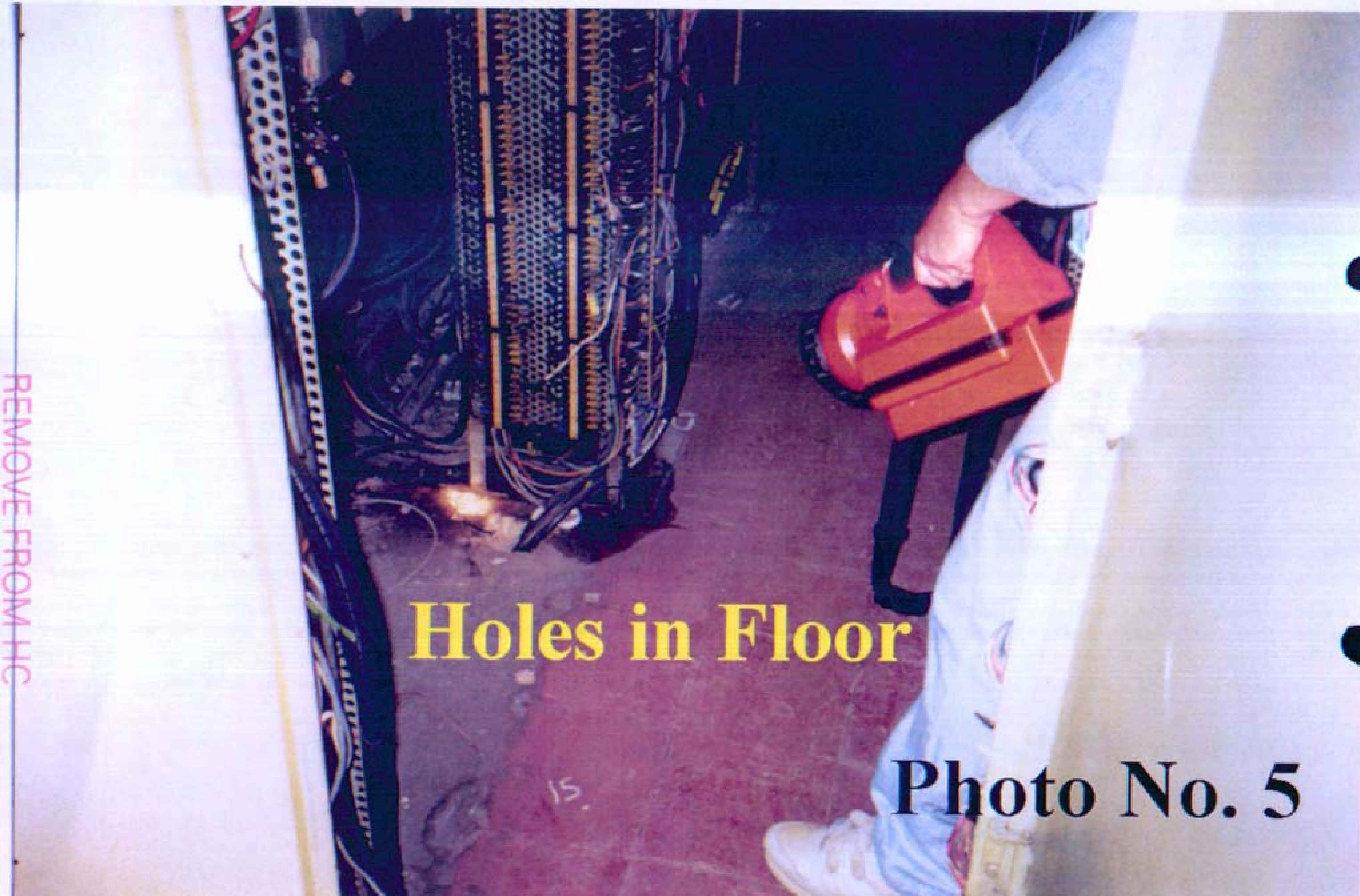
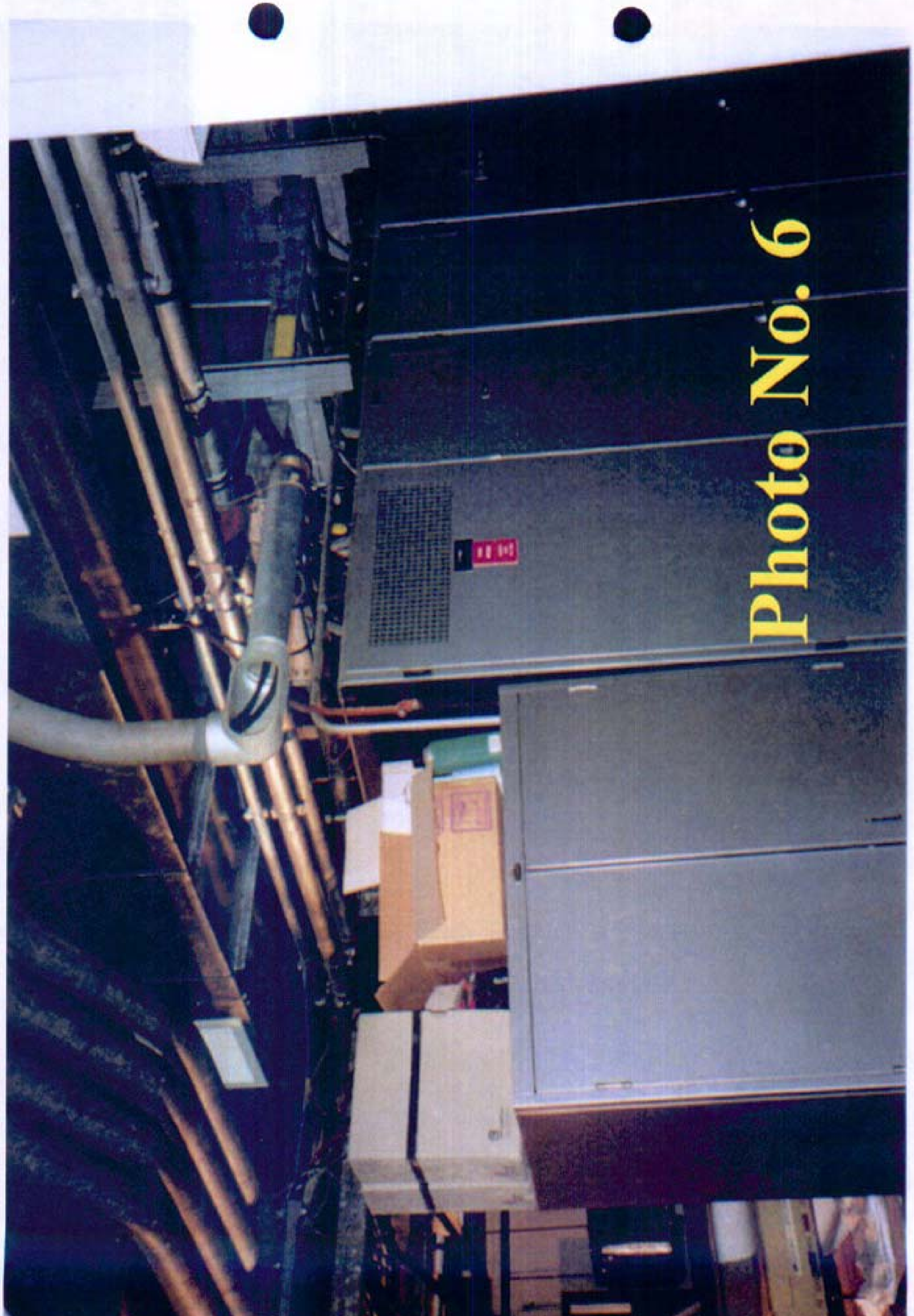


Holes in Floor

Photo No. 5



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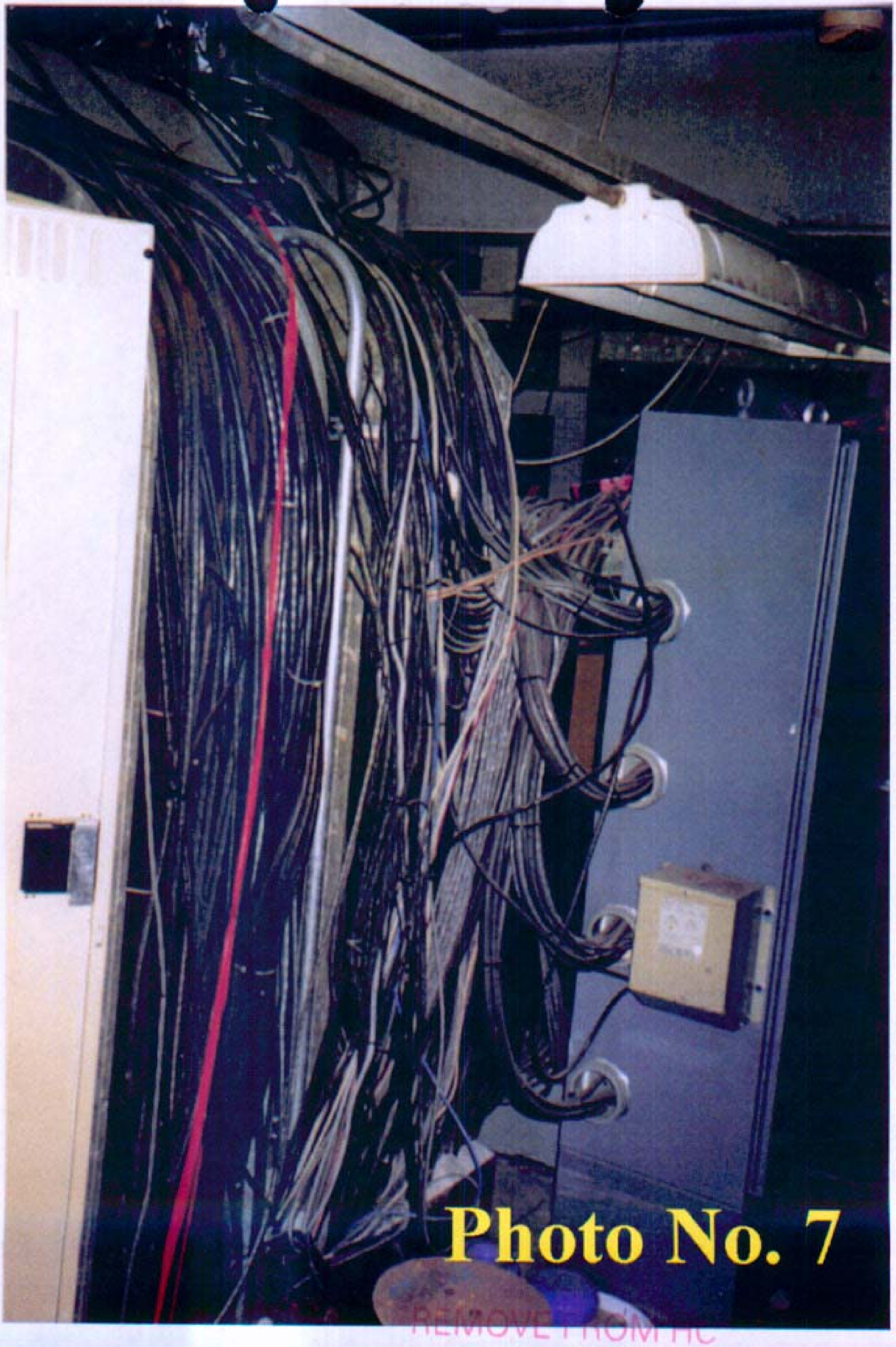

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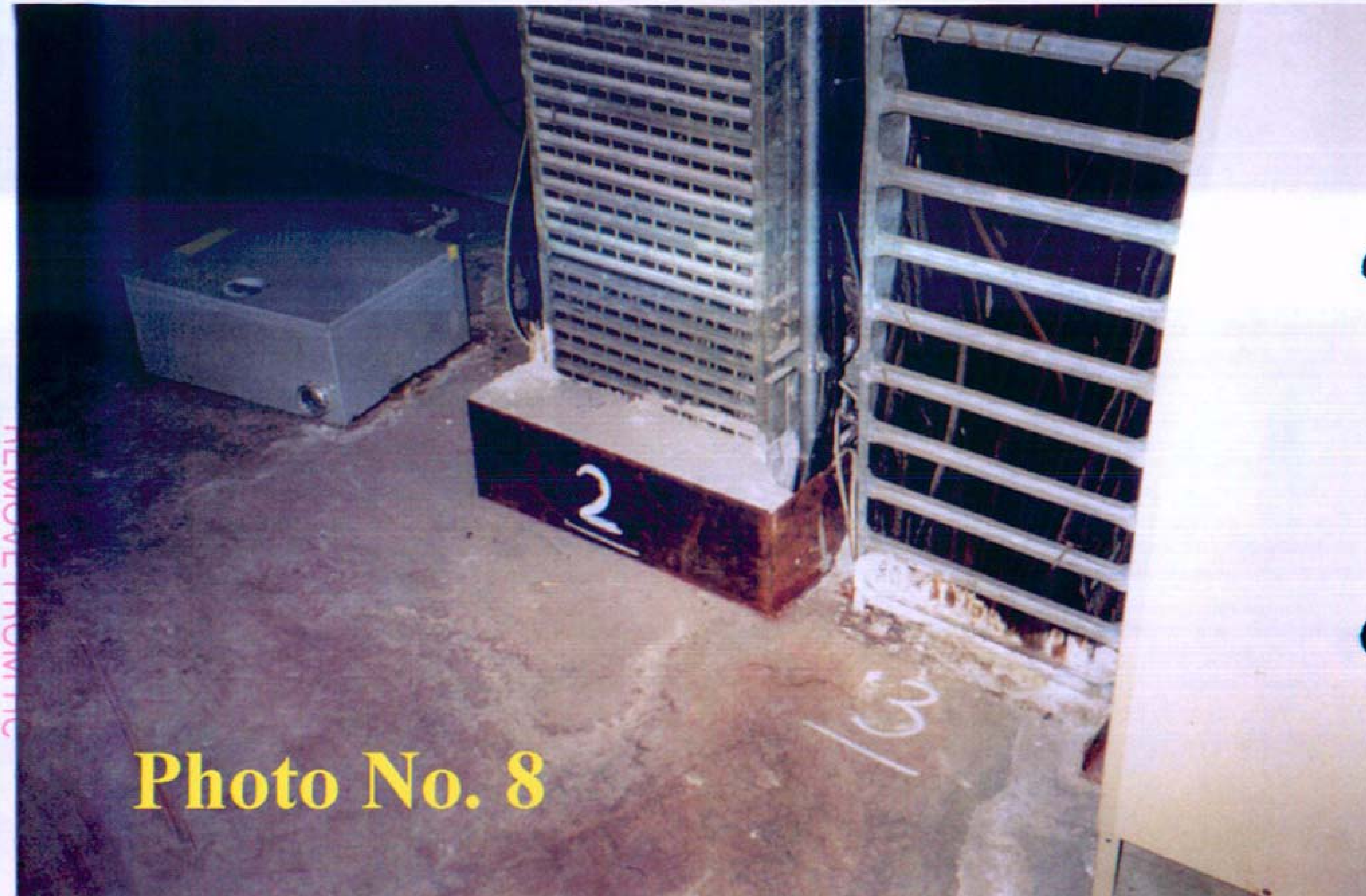

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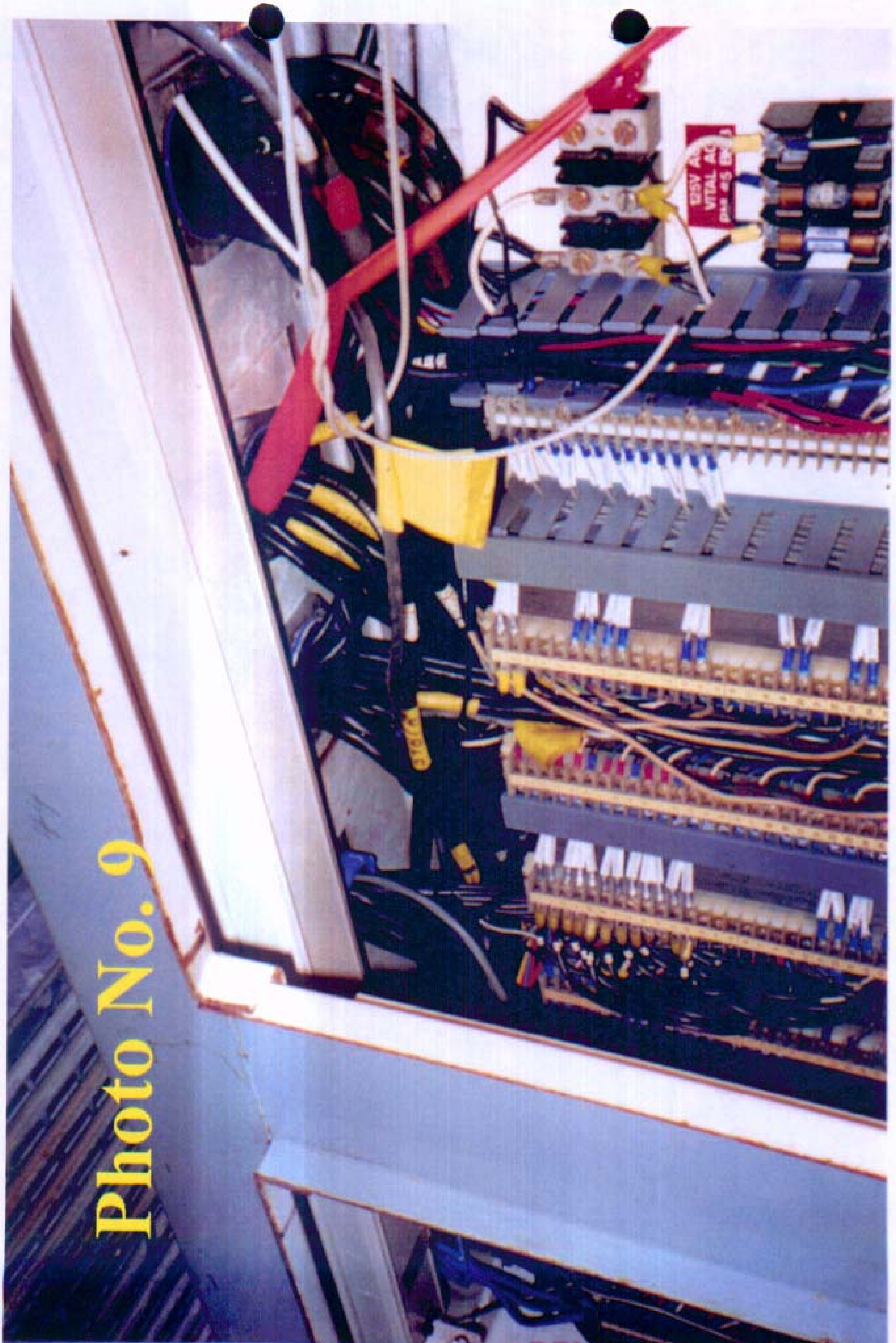

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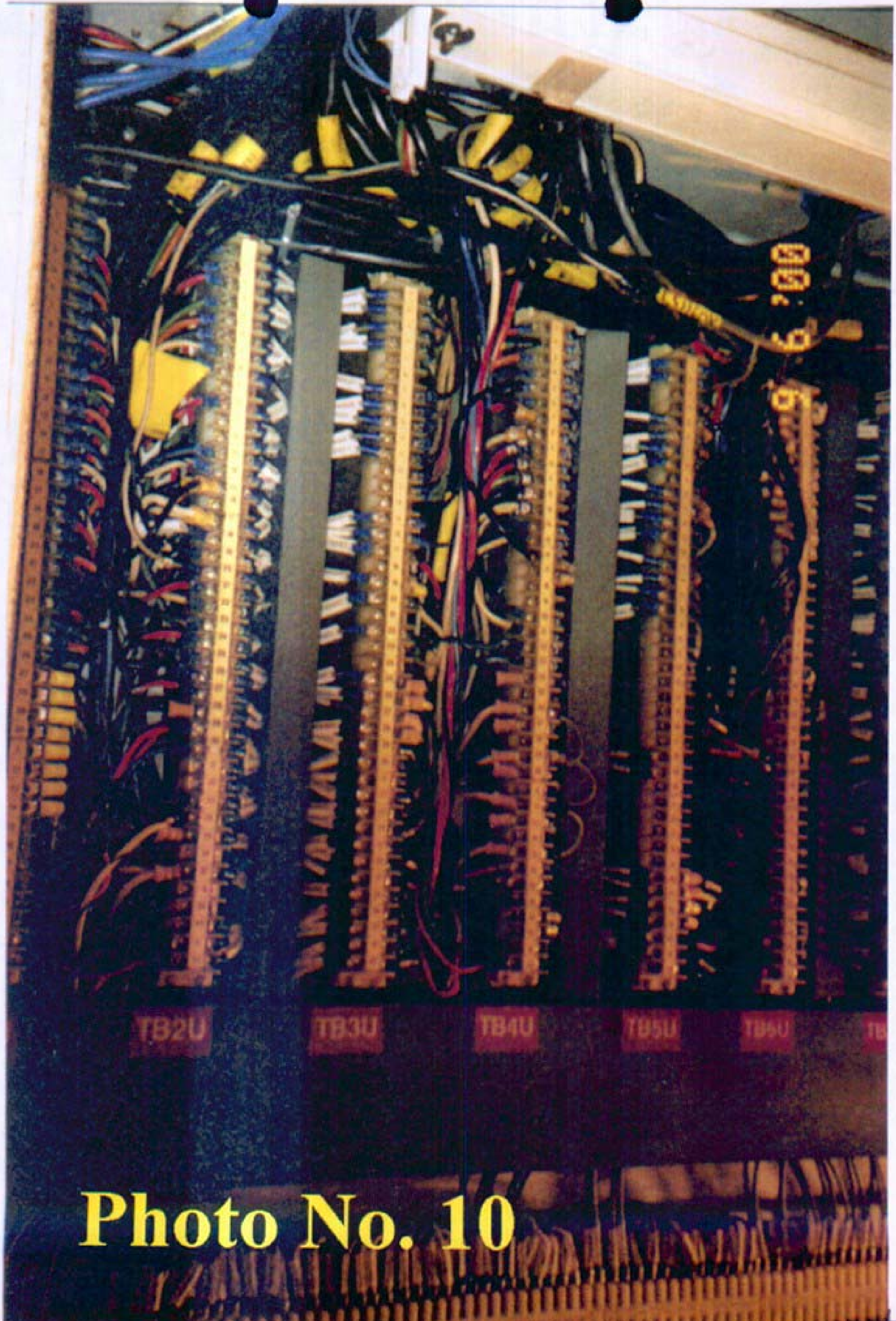

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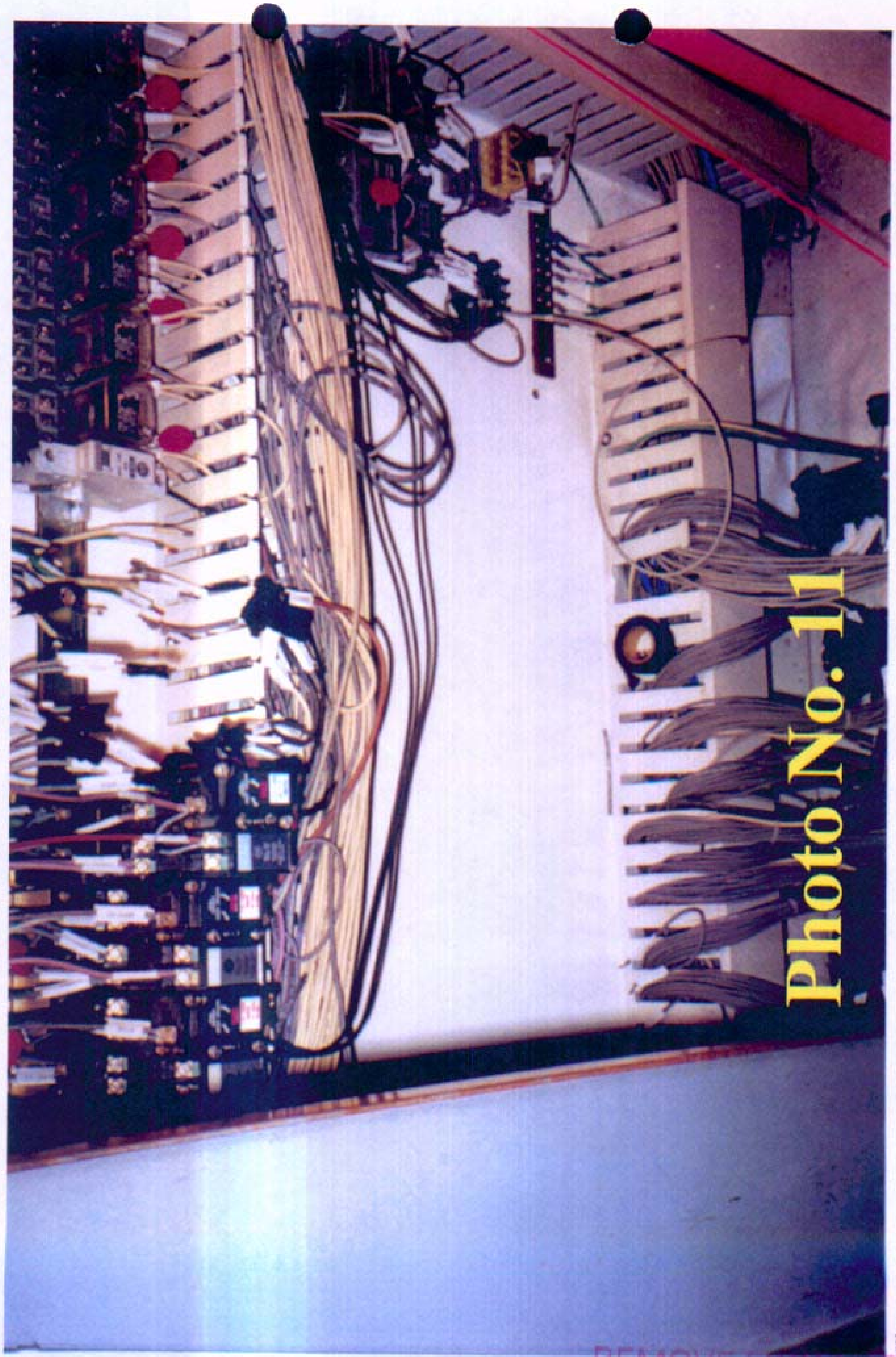


Photo No. 11

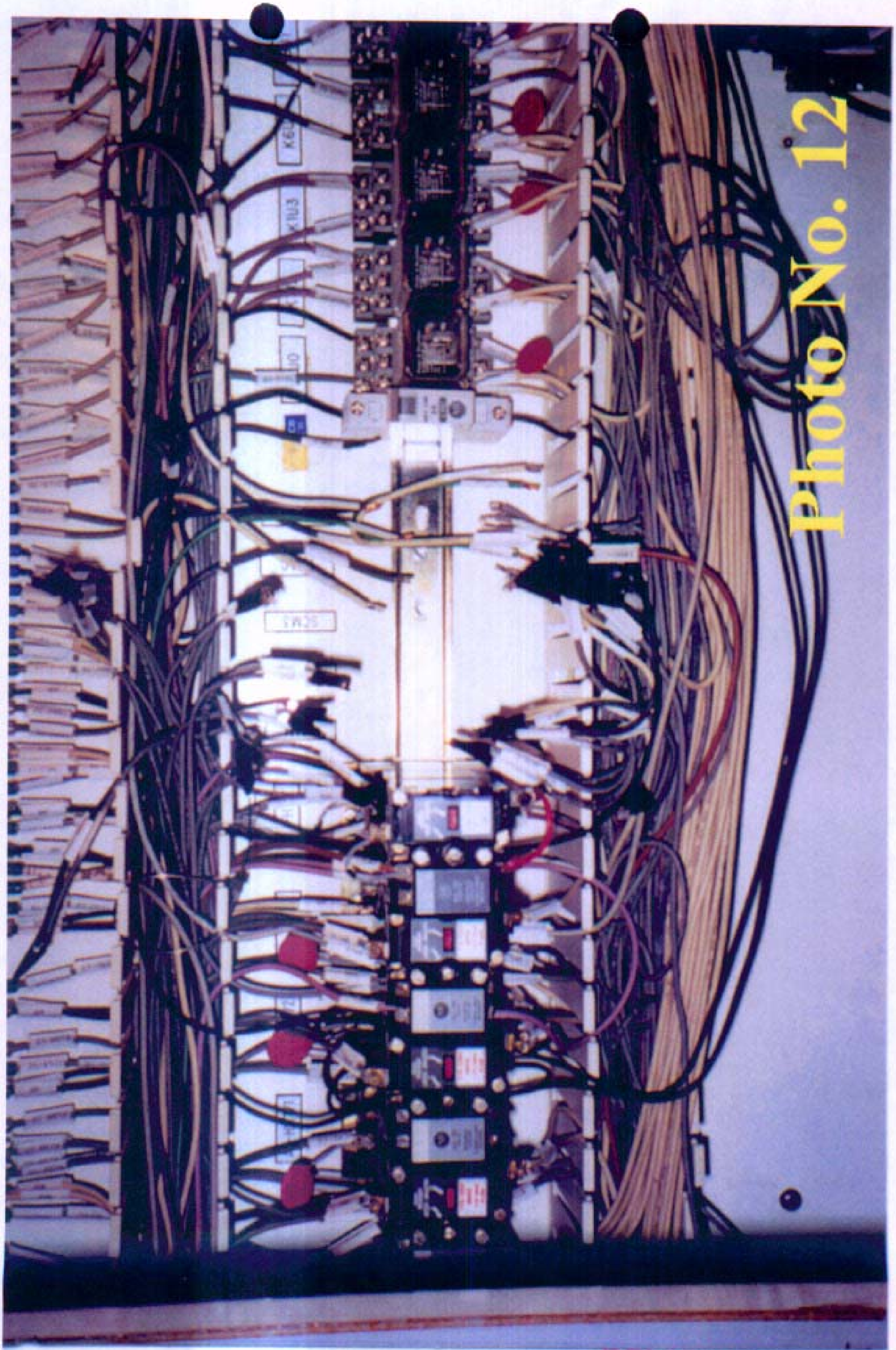
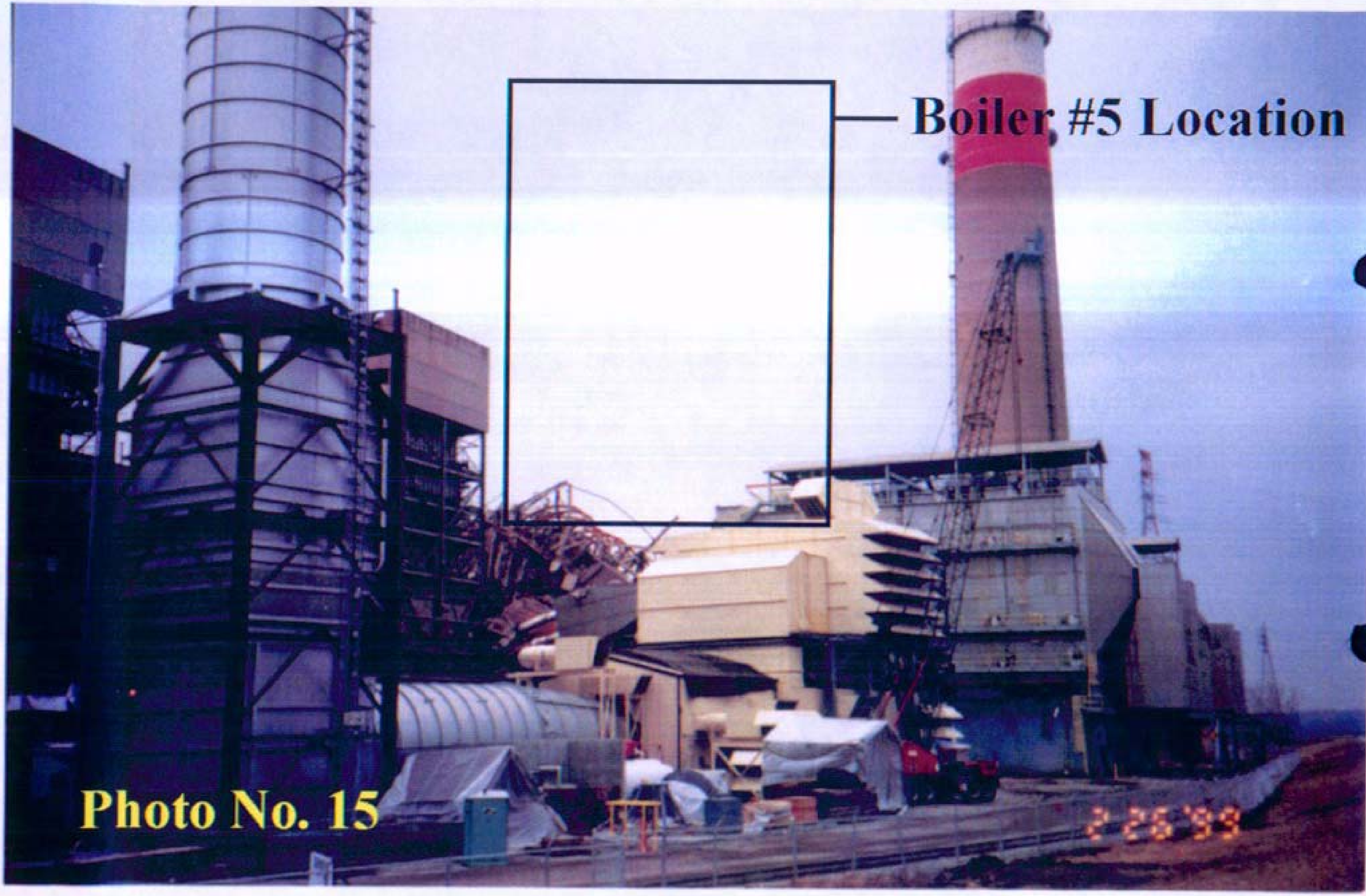


Photo No. 12

Photo No. 13

Photo No. 14
Looking South


Boiler #5 Location
Photo No. 15
2 26 99

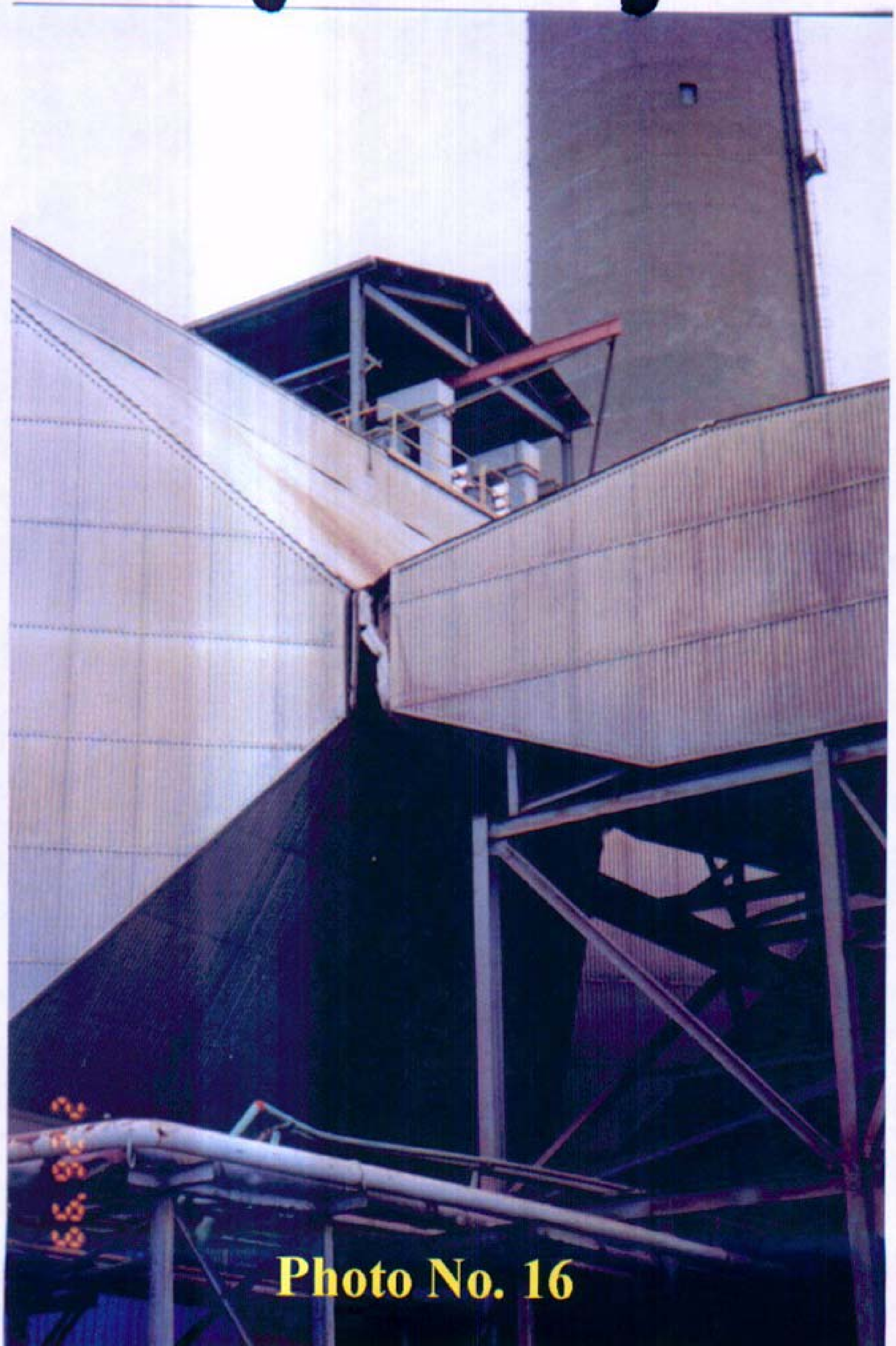
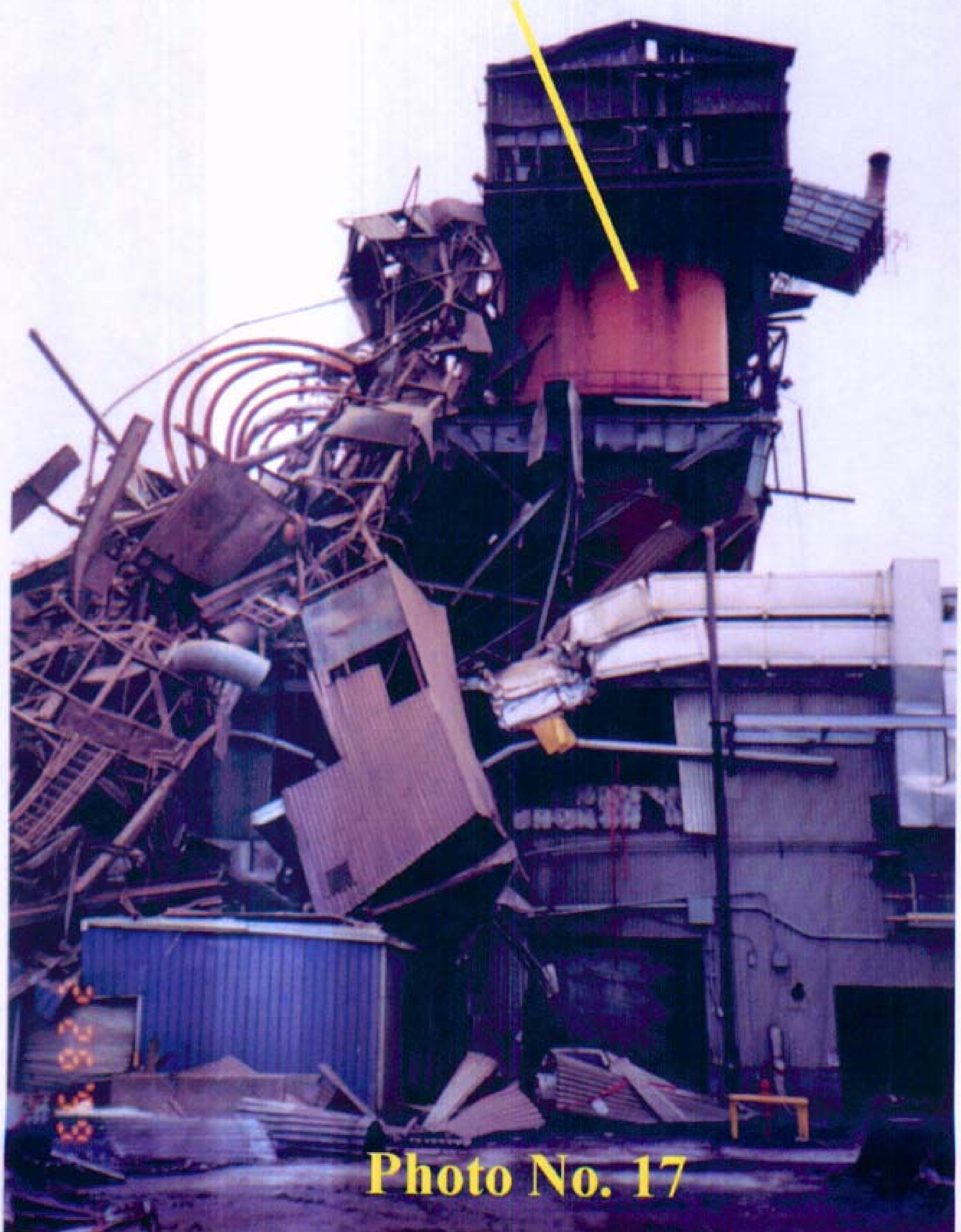


Photo No. 16

Coal Bunkers leaning toward turbine elevation



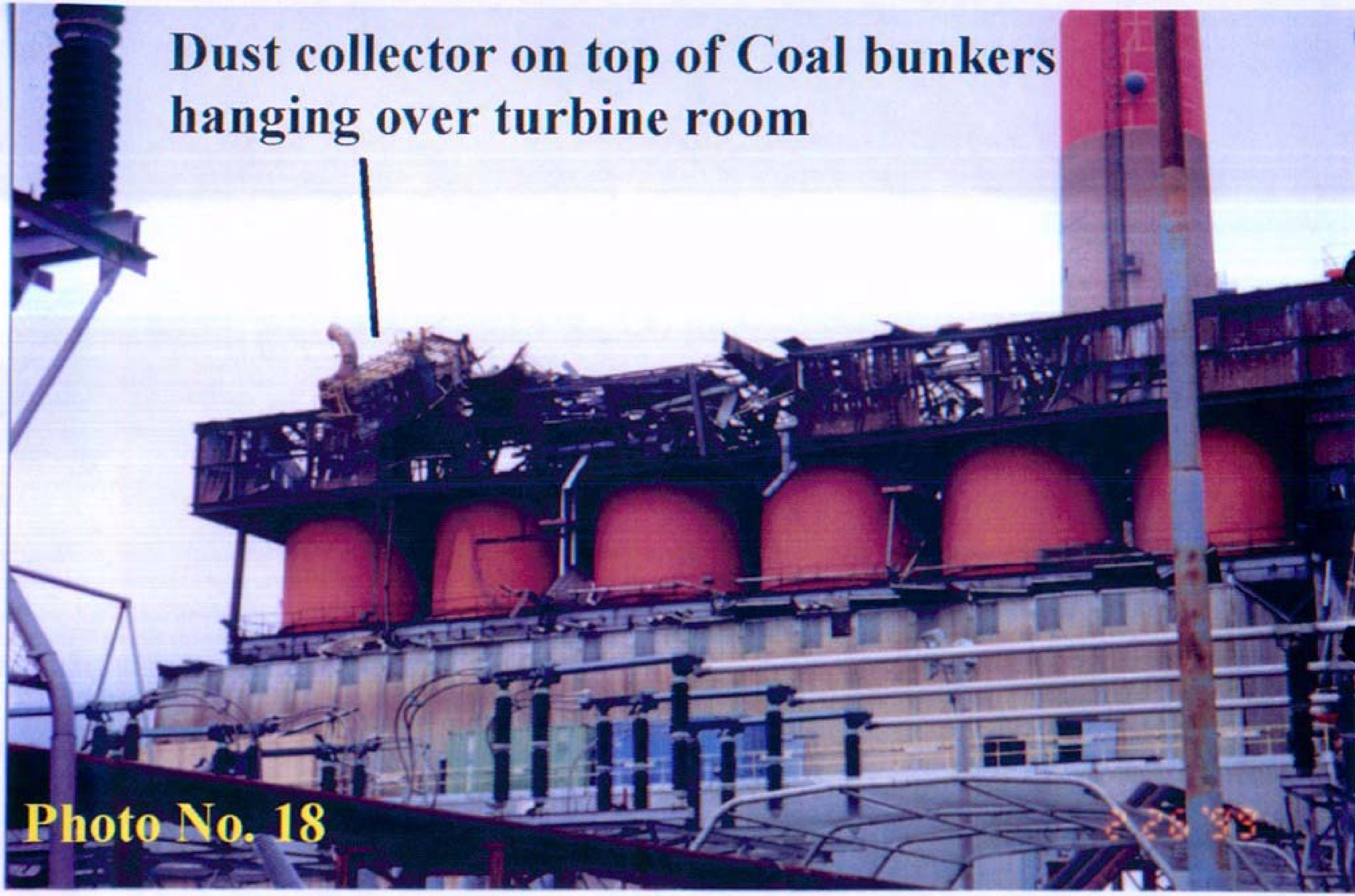
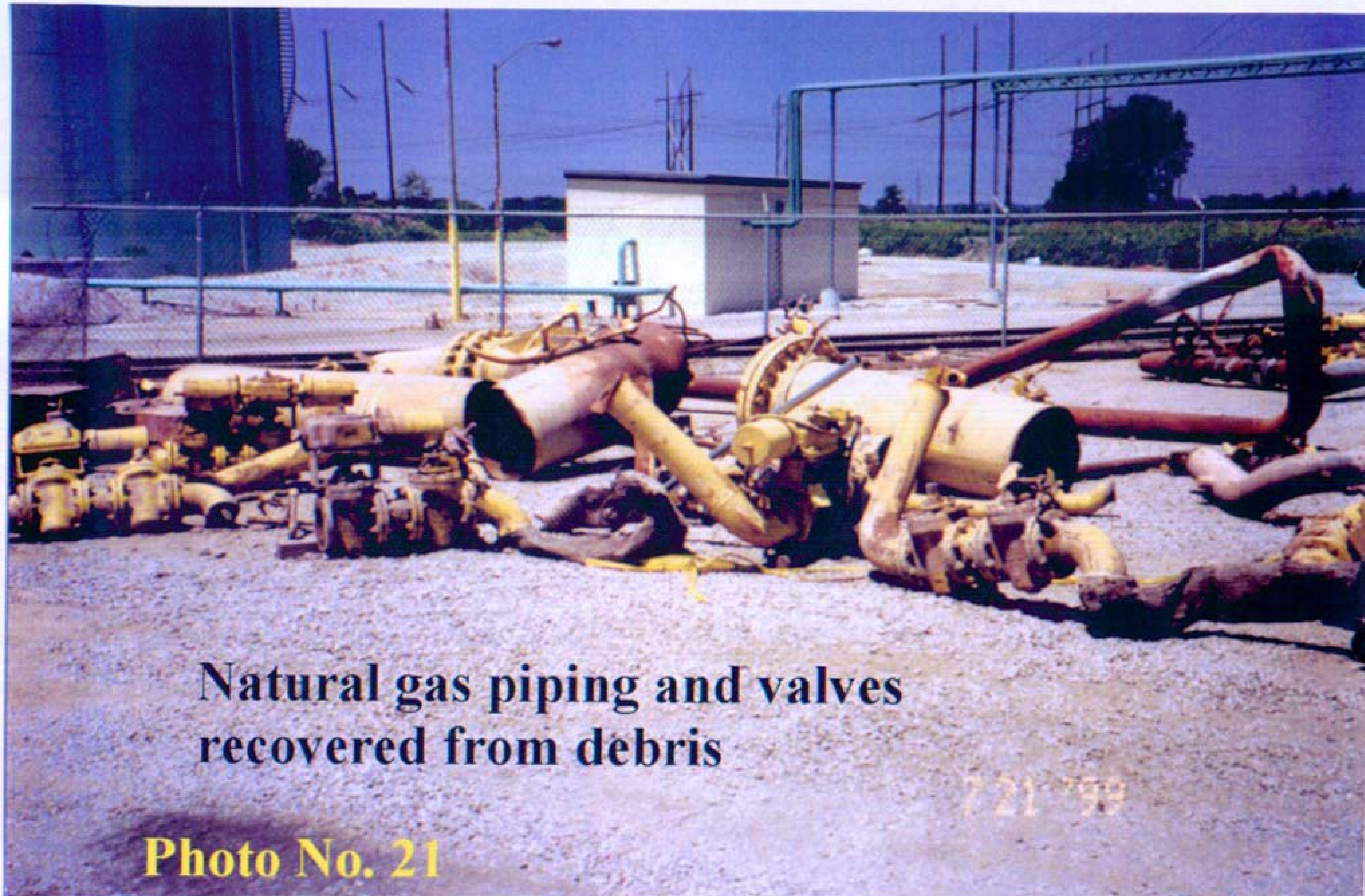

Dust collector on top of Coal bunkers
hanging over turbine room
Photo No. 18


Photo No. 19
Looking South

Photo No. 20
Looking South



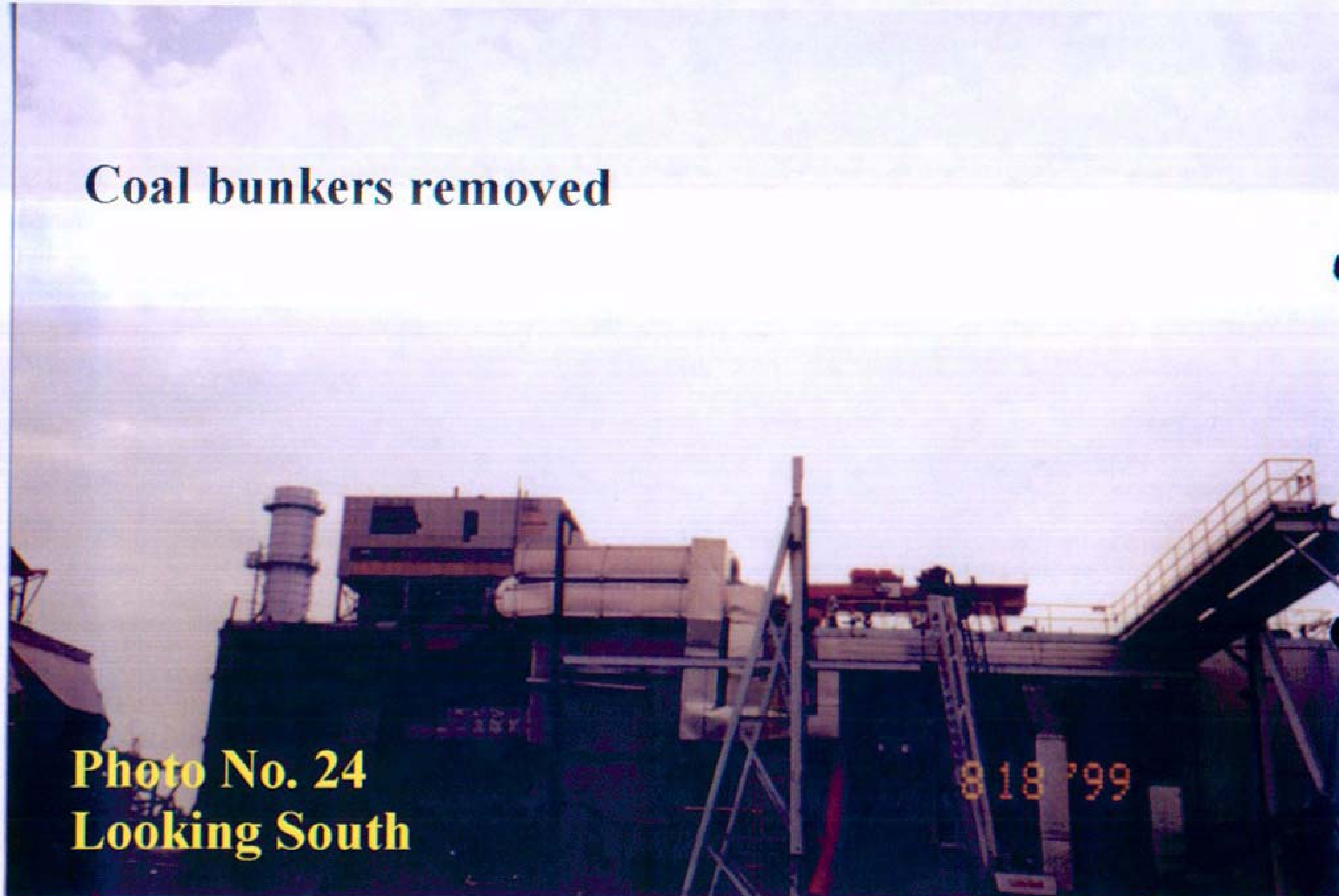
Natural gas piping and valves recovered from debris

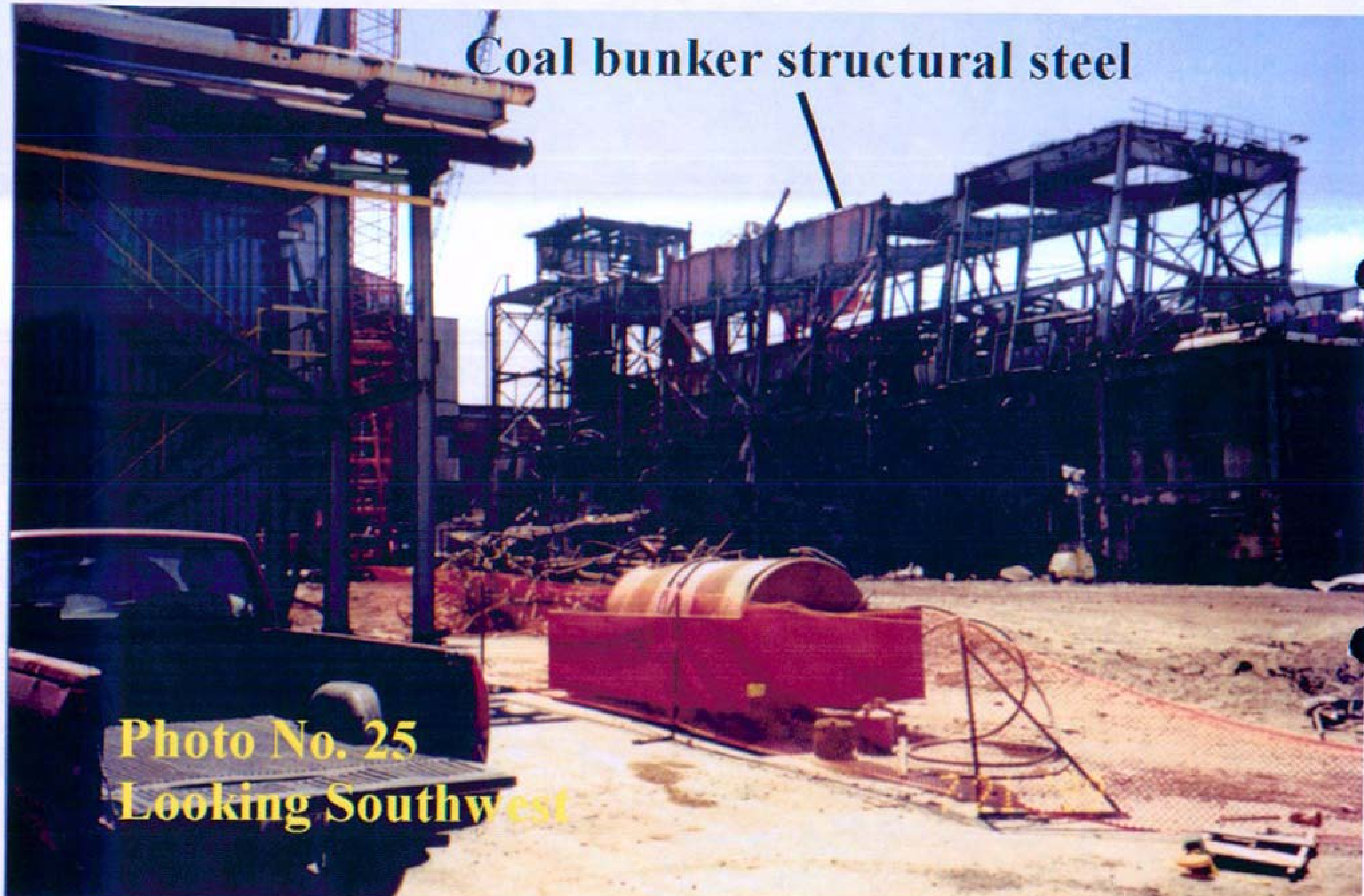
Photo No. 21

Photo No. 22

Corner burner section recovered from debris


Coal bunkers removed
Photo No. 23
Looking East


Coal bunkers removed
Photo No. 24
Looking South
8 18 '99


Coal bunker structural steel
Photo No. 25
Looking Southwest

Boiler removed
Coal bunkers removed

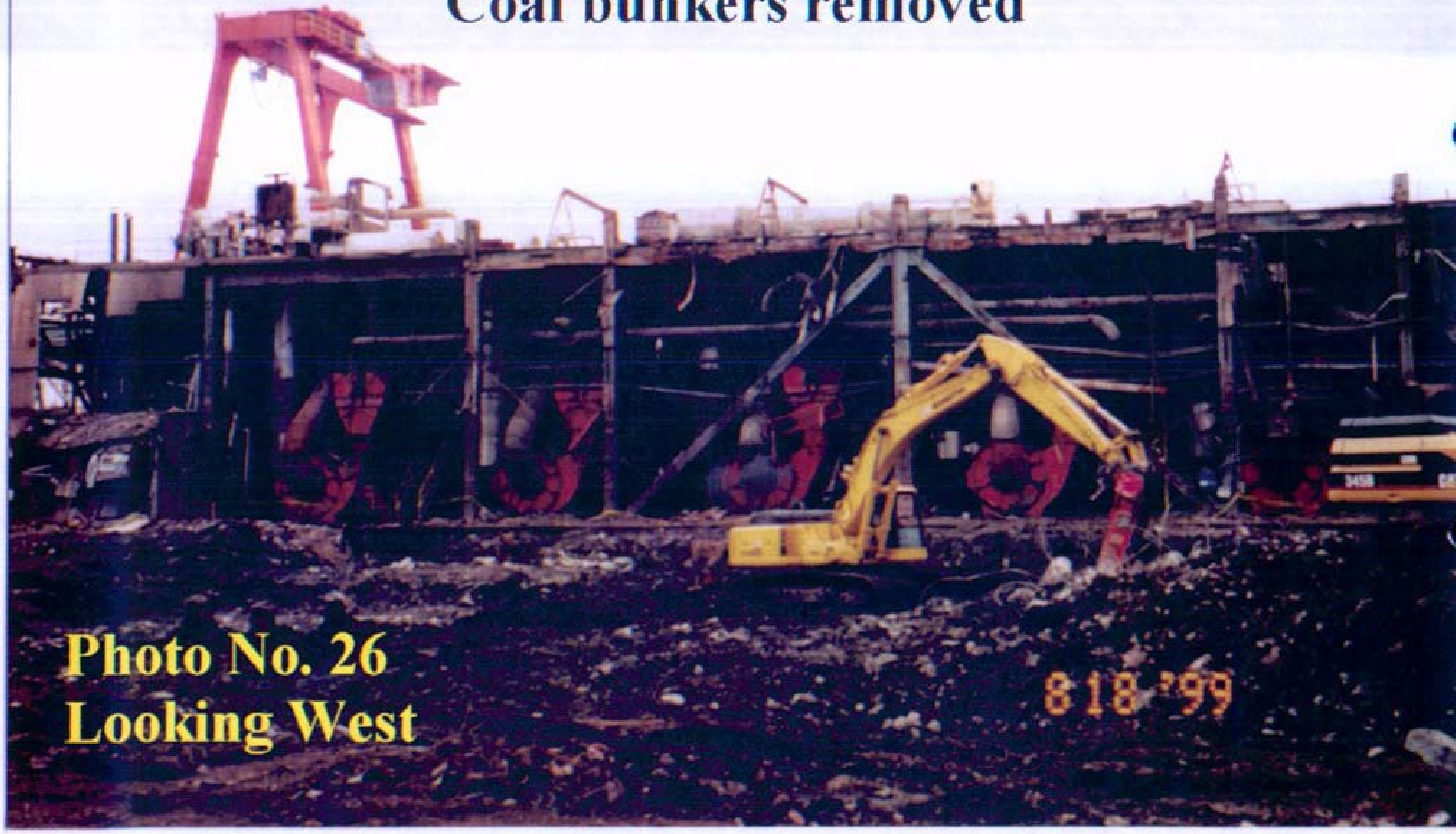
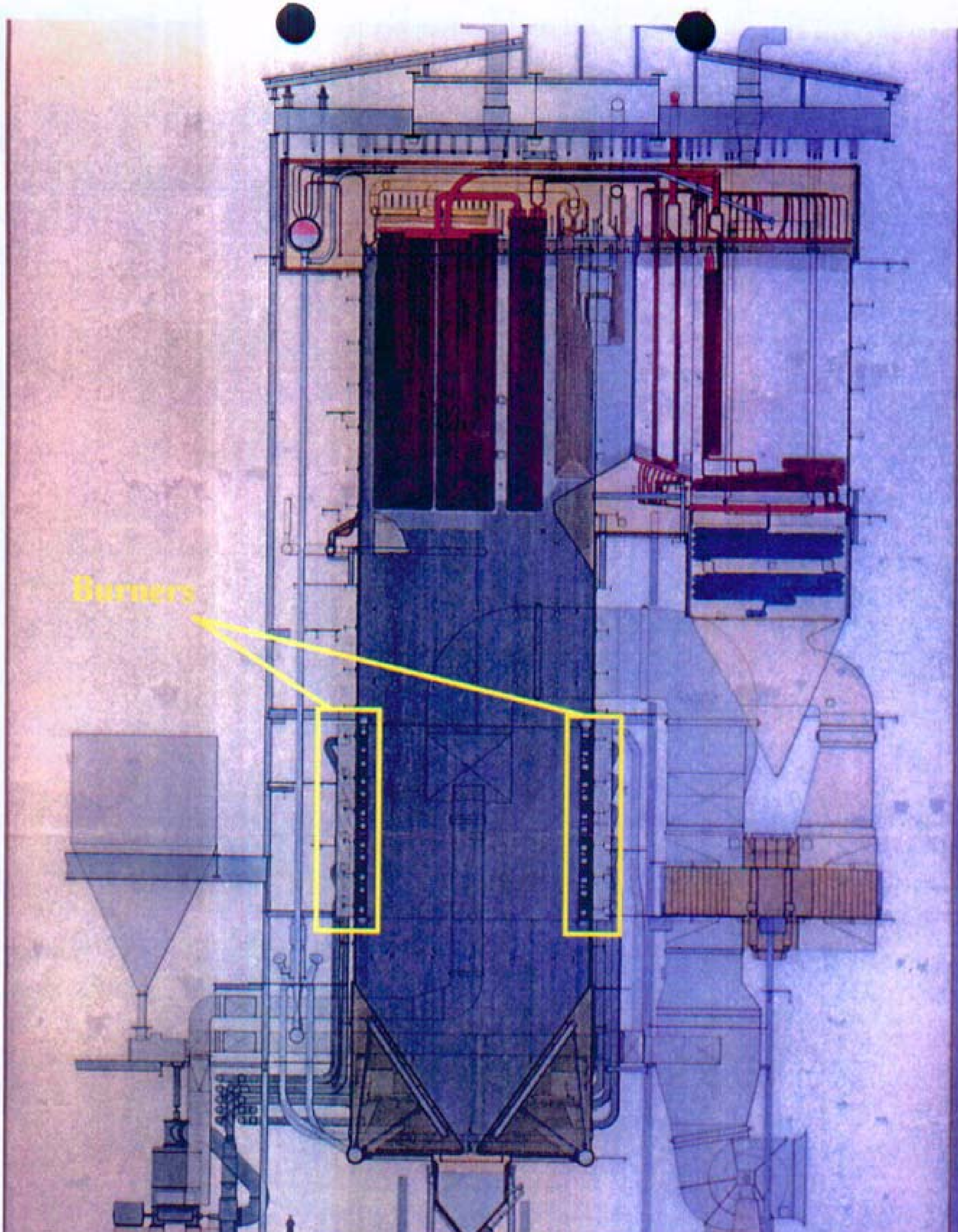



Photo No. 27
Looking East
10 4 '99


Photo No. 28
Looking North
10 4 '99

APPENDIX B

Figures



GENERAL ARRANGEMENT Figure 1-1

Burner management system

Identifying components affected by the waste water overflow

Items in red are the devices affect by the watse water overflow

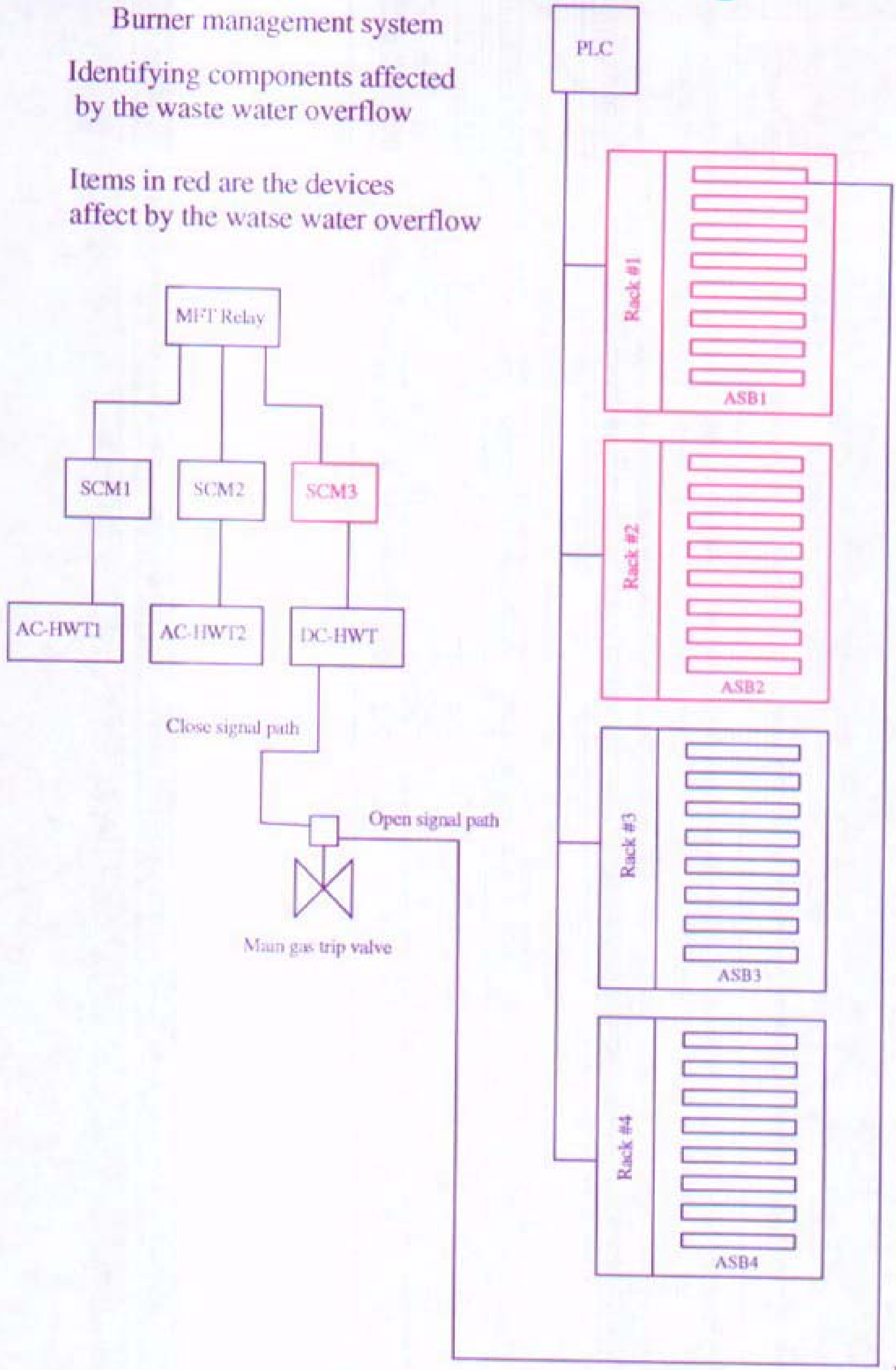
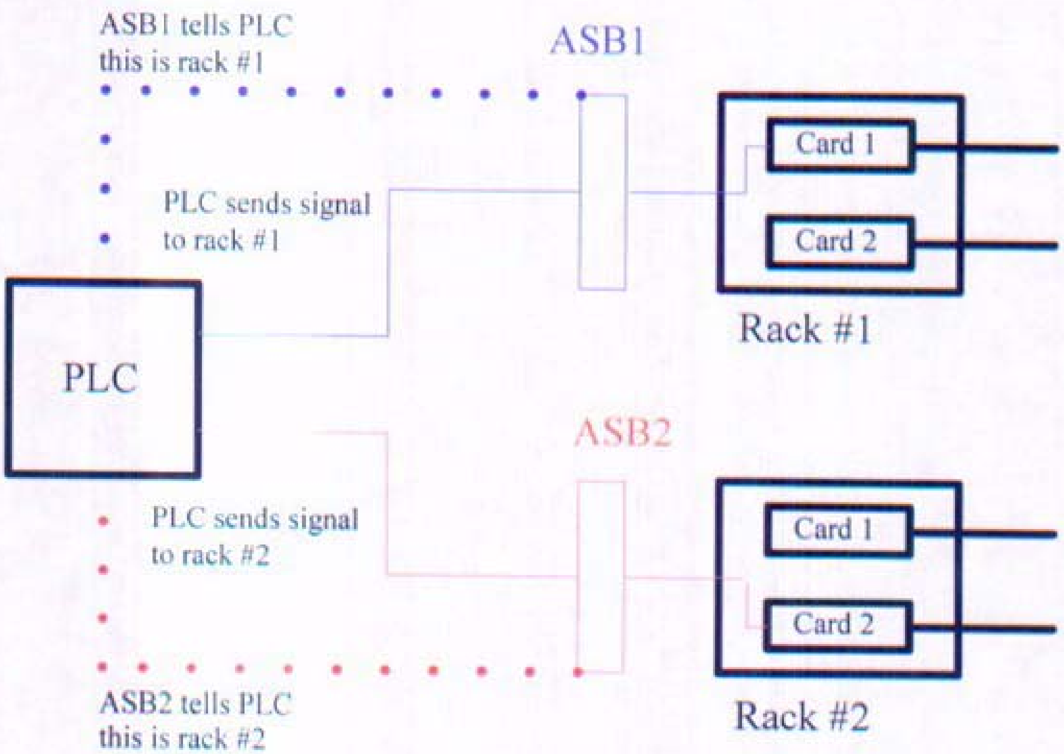
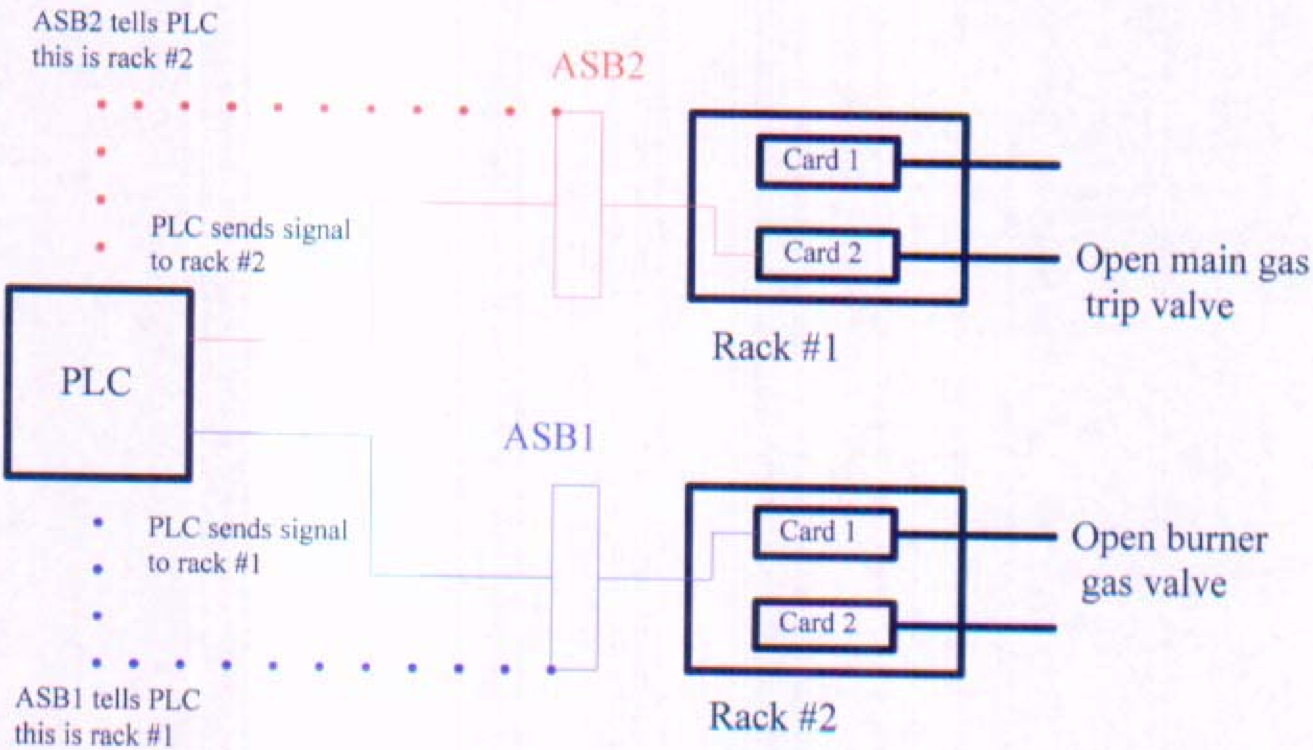


Figure 1-2



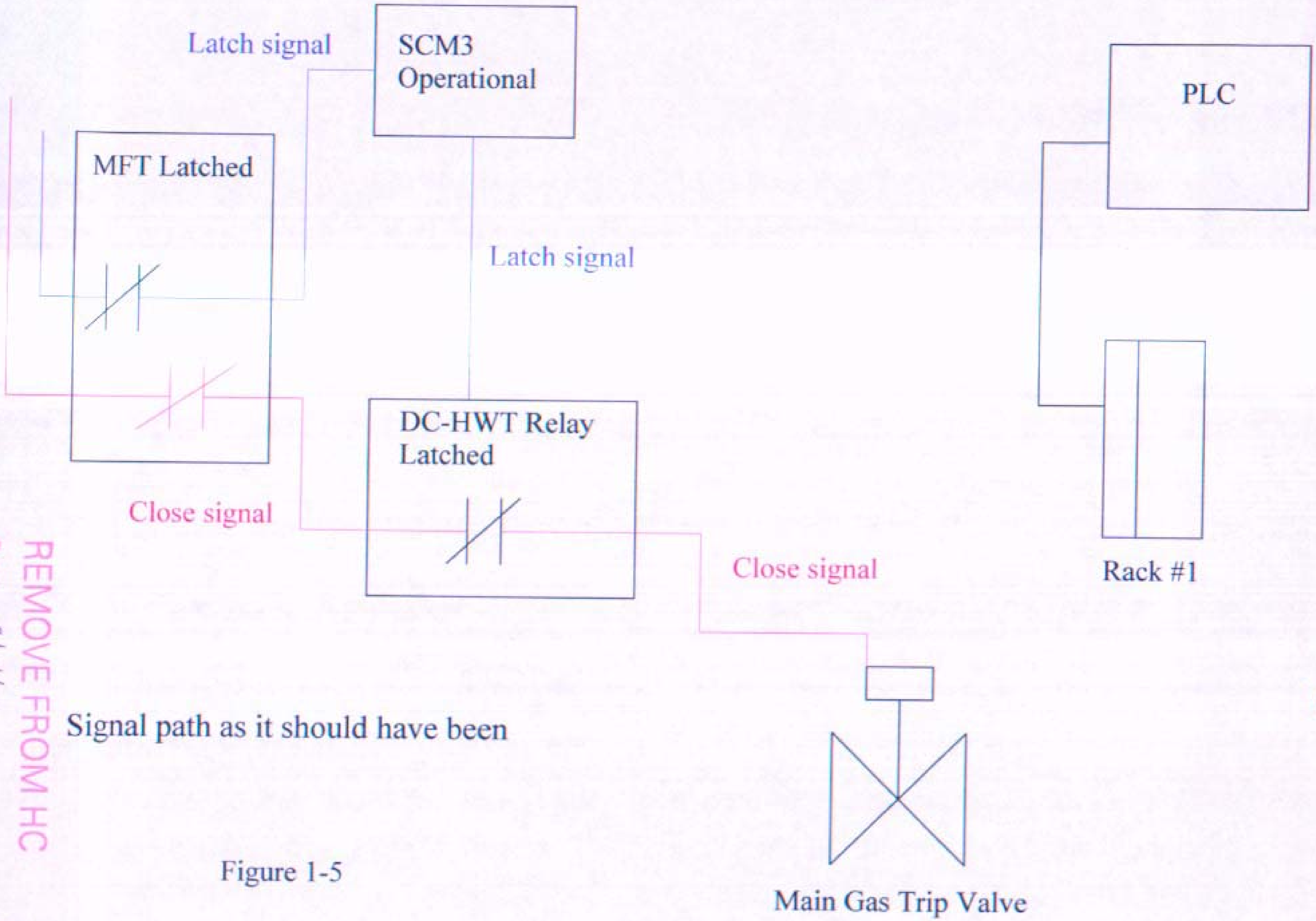
ASB Cards in correct location

Figure 1-3



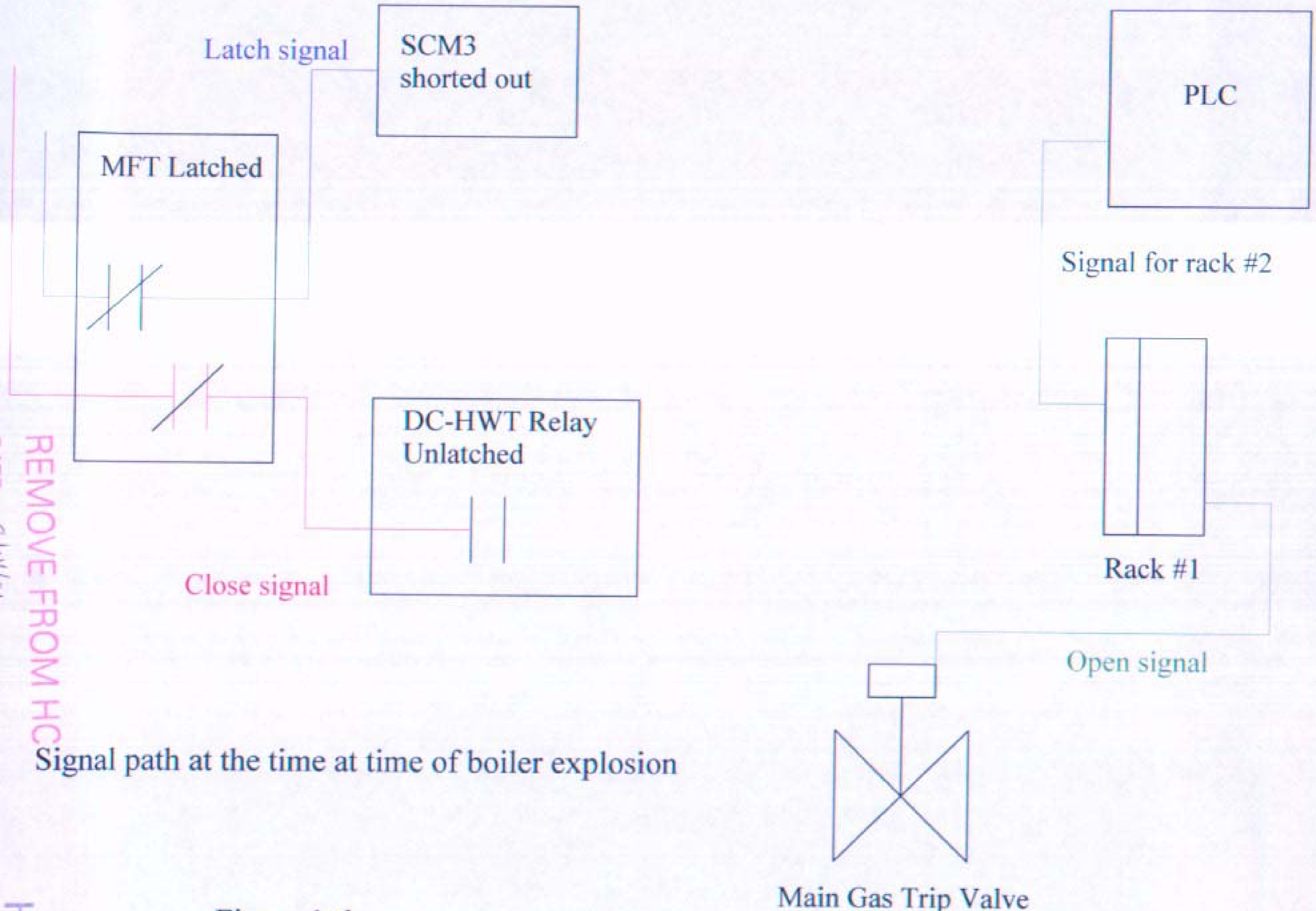
ASB Cards in wrong locations

Figure 1-4



Signal path as it should have been

Figure 1-5



Signal path at the time at time of boiler explosion

Figure 1-6

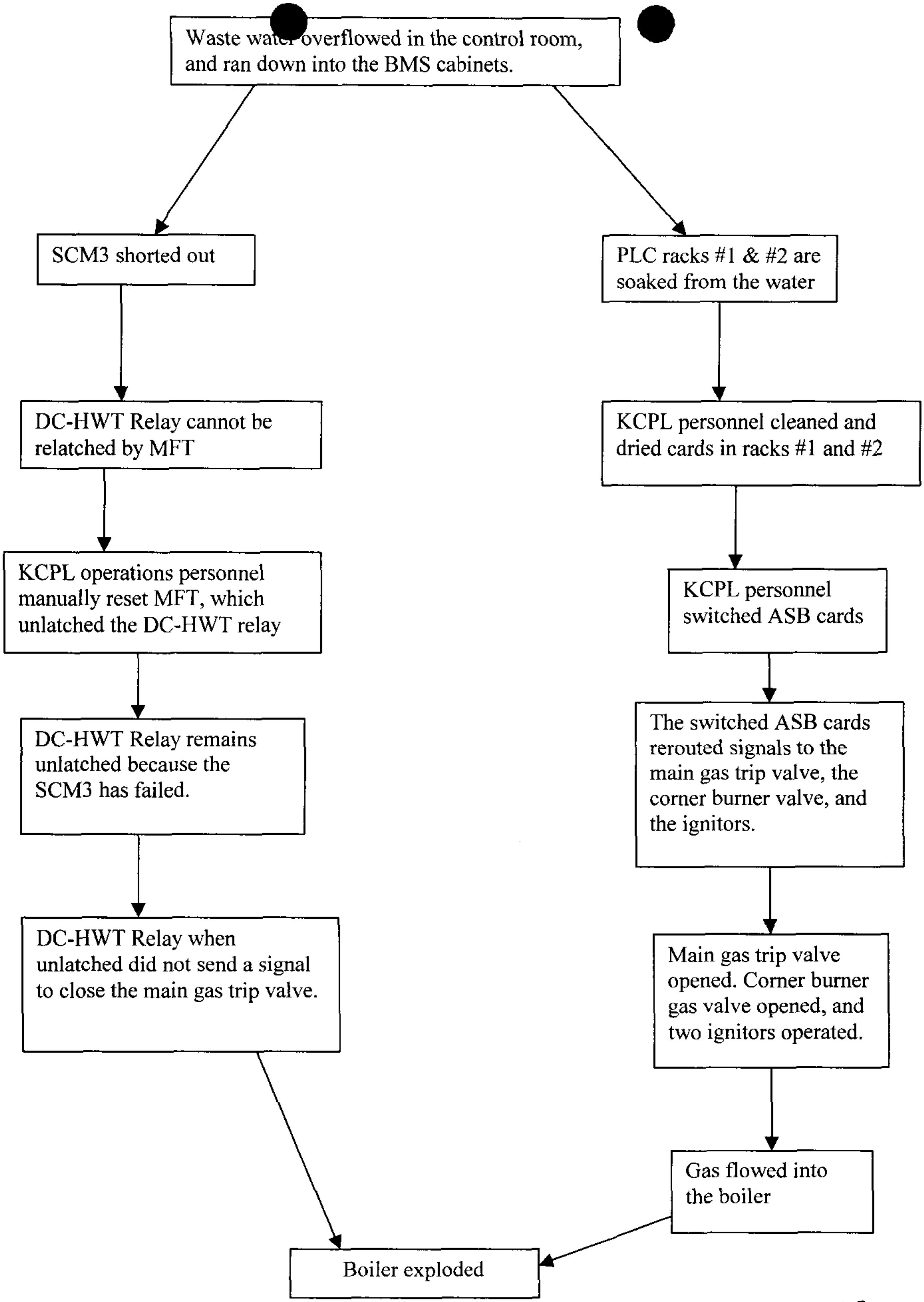


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Figure 1-7

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APPENDIX C

Glossary

GLOSSARY

ELECTRICAL TERMS

Contact:

A contact in an electrical device is a point at which two conductors or wires are connected and disconnected. Physically a contact is usually two pieces of metal which, when brought together to touch each other, allow an electrical current to pass through. A light switch is an electrical device with a contact. When the switch is moved from one position to the other the contact opens or closes. In the closed position, the contact completes the circuit, electrical current flows to the light, and the light comes on. When in the open position, the contact opens and the electrical current cannot flow to the light , so the light is off.

Relay:

A relay is a device that acts like a switch. Most relays are made up of two parts, a solenoid coil and contacts. When an electrical current is applied to a solenoid coil, the plunger inside of the coil moves. Attached to this plunger are the contacts.

So when the plunger moves, the contacts change positions. A simple relay has two conditions usually referred to as "energized" or "de-energized". A relay can have two types of contacts, usually referred to as "normally closed" or "normally open" in the de-energized condition. A relay may have either normally closed or normally open types of contacts, or even both types of contacts. So when a relay in a de-energized condition with a normally open contact is energized the normally open contact will close. When this relay is de-energized, the contact will open.

A relay is usually operated from a control type circuit that may not be the same circuit the contacts are in. Some times a relay is used to control a higher voltage circuit using a lower voltage circuit to operate. Relays with multiple sets of contacts can control several electrical devices at the same time, and are used to automate a system.

Latching relay:

A more sophisticated type of relay is a latching relay. This type of relay usually has two solenoid coils instead of one. In order for the contacts to change from one position to the other and back, each coil must be energized. When one coil is energized, the contacts change position, and the relay will lock in that position (latched). In order for the contacts to change back to the original position (unlatched), the second coil must be energized. Typically when both coils are energized the relay remains latched.

Solenoid:

Wired wrapped around a hollow core containing a metallic plunger. When electric current is applied to the wire the electromagnetic field produced moves the plunger.

Programmable logic controller:

A device, which allows internal software programming to be written to interface with electrical inputs and outputs. The device can be programmed with logic steps that when one or more specific inputs are received, it can send one or more specific outputs. Programming allows for certain internal logic steps to be completed before other internal steps can be initiated or completed.

The input signals and output signals are routed through computer cards. These cards are positioned in slots in groups referred to as racks.

BURNER MANAGEMENT

Burner management system:

Large utility steam boilers have systems in place to reduce the possibility that hazardous conditions will occur. One such system is the burner management system (BMS). This system is used to minimize the hazards involved in burning fuel in a boiler. As with all systems, a BMS is somewhat limited in what it can prevent. No system can be designed to react to every scenario or situation that is possible under all circumstances. Human interaction is still an important risk factor.

Standards for the prevention of furnace/boiler explosions are provided in the National Fire Codes published by the National Fire Protection Association. These standards describe procedures for the safe operation of the fuel systems on boilers. The standards cover the burning of oil, natural gas, and coal. These standards outline what procedures are needed to burn fuel safely in a boiler.

The burner management system's main functions are to allow for the safe burning of fuel, and to manage the fuel usage properly. The heart of this system has been usually a system of relays. Today modern programmable logic controllers are used, as well as incorporating the burner management system into the distributed electronic control system, which is now somewhat a standard for power plants. Whatever type of devices are used, the fundamental issue is some type of interlocking system that prevents certain operations from occurring before certain other conditions are met.

Part of the BMS is a purge of the boiler before light off. In order to ensure there are no lingering combustible gases or raw fuel in the boiler before a spark or fire is introduced into the boiler, air is blown or drawn through the boiler by large fans for a specific amount of time. This amount of time is pre-determined and counted off with a purge timer. These large fans are used during normal operation of the boiler to supply air for the combustion of the fuel and to ensure the gases from the combustion are removed from the boiler.

The boiler has certain monitoring devices that indicate and track operating parameters and/or operating conditions. Certain conditions require the boiler to be tripped automatically, or the fuel stopped automatically. Some conditions for a boiler trip are furnace pressure high or low, low water level in the drum, loss of air flow, or loss of flame. A boiler is operated in such a manner that these conditions as well as many other parameters are monitored and adjusted by the boiler control system. The boiler operator monitors the operation of the boiler and the control system and may be required to make adjustments to prevent the boiler from operating at the conditions that would be unsafe.

The control system is designed to trip the boiler when certain conditions exist without any interaction from the boiler operator. A trip due to these conditions happens without operator intervention and usually without a determination if it is a false condition. Because the monitoring devices are not perfect, the operator also has the ability to trip the boiler manually if he decides there is a hazardous condition, or he believes the automatic devices are not operating correctly.

When the interlock device, sometimes referred to as the "Master Fuel Trip", is in the "tripped" position, it prevents fuel from entering the boiler. When it is in the "reset" position, it allows for other devices to operate allowing fuel to enter the boiler. For the interlock device to be in the reset position, certain conditions have to be met, one of which is a purge must have been successfully completed on the boiler. To allow the boiler to be lit off, the interlock device must be in the reset position. The interlock device then can be tripped to shut off fuel to the boiler. When the boiler is off the interlock device should be in the tripped position.

BOILER TERMS

Boiler light off:

The act of igniting a relative small amount of fuel to begin the process of bringing the boiler up to operating pressure and temperature. This is usually done with small burners called ignitors.

Ignitors:

A small burner used to start the process of bringing the boiler up to operating pressure and temperature. Ignitors usually use fuel oil or natural gas as a fuel. The ignitors are used to light off the main coal burners, and sometimes are used to insure the fire in the furnace is burning properly.

Burner:

A device where fuel and air enter, are mixed and then ignited at the exit of the device. Usually a boiler has several burners, and the largest boilers have several burners at several elevations of the furnace.

Burner vent valves:

The natural gas burner piping system has vent valves, which are opened when the boiler is taken off to remove any residual gas that may be present in the piping system. These vent valves are closed when the boiler is started up and when its burning natural gas.

Furnace:

That section of the boiler where the combustion of the fuel and air mixture takes place.

Boiler:

A piece of equipment consisting of pipe, headers and drums in which fuel is burned to turn water into steam.

Water tubes:

Steel tubes approximately 2" to 3" in diameter containing water usually surrounding the furnace area on four sides forming a square. The combustion of the fuel and air mixture in the furnace area heats the water inside the tubes to steam.

Furnace pressure/furnace draft:

The boiler is not a pressure vessel. Some parts of a boiler are designed as a pressure vessel, such as the steam drum and certain headers. A pressure vessel is designed specifically to operate at and maintain its integrity at certain pressures. A boiler steam drum may be designed to withstand an internal pressure of 3000 pounds per square inch. A boiler is made up of tubes welded together, but not in such a way as to make it a pressure vessel. The area of the boiler where the fuel burns is referred to as the furnace. The furnace pressure must be monitored to make sure it does not exceed the design limits. Both high pressure and low pressure are dangerous. High pressure would make the boiler furnace expand outward damaging anything close to the boiler and also would allow the fire or fuel to escape. Low pressure, or pressure below atmosphere in the furnace, would cause the boiler furnace to collapse in on itself.

Drum level:

The boiler is made up of four walls of tubes that contain water in them. The fire in the furnace causes the water to turn to steam. This steam rises and is collected in a large pressure vessel known as the steam drum. Also in this drum is water, which is fed down to the bottom of the furnace and into the wall tubes. The tubes that make up the walls of the furnace are made of steel so water must be inside of them to dissipate the heat from the fire or they will fail. Thus, it is important to keep water in the tubes, which is done by monitoring the level of water in the drum. If the level of water is low, then there is a possibility that the wall tubes could run out of water and could over heat and fail.

Air flow:

In order for combustion to take place in the furnace the fuel must have a certain amount of air available. Large fans called "draft fans" are run to supply air to the furnace for the combustion, and remove the gases resulting from the combustion from the furnace in order to make room for more fuel and air. Fans both push the air in and pull the combustion gases out of the furnace, or there are separate fans that push the air in and fans that draw the gases out of the furnace. On a pressurized boiler there are a set of forced draft fans. On a balanced draft boiler there are two sets of fans, forced draft and induced draft fans. Without proper air flow, or no air flow, and the fuel still entering the furnace a possible explosion could take place.

Loss of flame:

If there were no continuous sustainable fire in the furnace, there would be differing amounts of unburned fuel and air in the furnace, which could cause an unstable fire, which could lead to no fire. If the fuel were not shut off, there would be fuel entering a hot boiler. This fuel could ignite and lead to an explosion. Boilers are equipped with some type of device that will recognize a no flame condition in the furnace.

APPENDIX D

Estimation of waste water overflow

Estimation of the amount of waste-water overflow

NOTE: Based on information provided by KCPL

The sump pit for lift station #1 appears to be a fiberglass basin **60"** in diameter and **120"** deep, which calculates to **196** cubic feet of total volume. There is a float level control that determines the two levels in the basin at which the pumps will turn on and off. If these levels were known, Staff could make a better estimate of the volume of water. However this information has not been provided by KCPL to the Staff.

The Staff has made some assumptions and estimations in order to estimate the possible total amount of water that could have been pumped into the control room. In order to determine the likely volume of water, the estimated volume of the two pumps and piping must be removed from the total calculated volume. Also, there is a volume in the basin not used because (a) the pump requires a minimum level of water to operate, and (b) an allowance must be made because of the assumption that the floats for level control would not allow the water to reach the top of the basin. Subtracting these volumes from the total calculated volume leaves approximately **178** cubic feet. This volume will hold **1,330** gallons of water.

All of the actual amount of water the pit was designed to hold was pumped out of the basin because the level controls turned the pump on and turned it off. However, this does not mean that all of this water would have gone to the control room. The cleanout on the first floor was open and water was flowing out of it. Because the toilets on the third floor were at a higher elevation than the cleanout, the amount of water flowing out of the toilets could have been less than what was coming out of the cleanout opening. In addition the pumps could have been pumping a small amount through the constriction in the pipe to lift station #2.

Because of all these factors, Staff has no way to estimate accurately the amount of the water in the control room. **With waste water coming out the cleanout at a lower elevation than the toilets on the third floor level, it would be a fair assumption that less than the total amount of water went to the control room.** Based on this assumption, Staff estimates that less than 700 gallons of water were pumped to the control room.

REMOVE FROM HC

DATE 8/14/01

HC

Volume of basin = **3.1416 x 2.5 x 2.5 x 10 = 196.35 cu.ft.**

Estimated volume of basin for pump operation = **3.1416 x 2.5 x 2.5 x 3/12 = 4.9 cu.ft.**

Estimated volume of basin for float operation = **3.1416 x 2.5 x 2.5 x 6/12 = 9.82 cu.ft.**

Estimated volume of pump and piping = **3.73 cu.ft.**

Estimated volume of usable basin = **196.35 - 4.9 - 9.82 - 3.73 = 177.9 cu.ft.**

Water = **7.48 gal/cu.ft.**

Estimated gallons of water pumped = **7.48 x 177.9 = 1330.7 gallons**