Attachment 3

0CAN071303

Stator Drop Root Cause Evaluation (Non-Proprietary)

Entergy Operations, Arkansas Nuclear One (ANO)

Root Cause Evaluation Report

Unit 1 Main Turbine Generator Stator

CR-ANO-C-2013-00888; Event Date: 03-31-2013

REPORT DATE: 07-22-2013, Rev. 0

Position	Name	Date
Evaluator	J.J. Nadeau	07-22-2013
Reviewer	L.A. McCarty	07-22-2013
O&P Review	S.C. Marrs	07-22-2013
Responsible Manager	D.E. James	07-22-2013
CARB Chairperson	M.R Chisum	07-22-2013

Problem Statement

At approximately 0750 on 3/31/2013, during movement of the Unit 1 Main Turbine Generator Stator (~524 tons), the temporary lift assembly failed resulting in loss of life, loss of off-site power to Unit 1, structural damage to the Turbine Building and physical injuries.

Event Narrative

Event

Entergy Operations, Inc. (Entergy) contracted with Siemens Energy, Inc. (Siemens) to perform Generator Modernization on Unit 1 Main Turbine Generator Stator (stator) during Arkansas Nuclear One (ANO) 1R24 refueling outage. Siemens subcontracted with Bigge Crane and Rigging Co. (Bigge) for crane and rigging services to remove the original stator and install the Unit 1 refurbished stator. A description of the intended lift process is included as Exhibit 1.

At the time of the event, ANO-2 was operating at 100% power and ANO-1 was in day seven of the 1R24 refueling outage. ANO-1 personnel had just completed filling the refueling canal and were in the process of checking out refueling equipment. The Bigge girders and strand jack lifting device had been raised into place during the March 30th night shift and the lift of the stator had begun late in that shift.

At approximately 0750 on March 31, 2013 the temporary lift assembly used to lift and transport the ANO-1 stator from the turbine building failed resulting in the ~524 ton stator dropping onto the ANO-1 turbine deck (Elev. 386') and then rolling and falling onto the transport vehicle parked in the train bay (Elev. 354'). Upon the failure of the lift assembly, its structural members came down onto the ANO-1 and 2 turbine deck resulting in the death of one individual, ten other injuries requiring offsite medical treatment, and multiple first aids. The impact of the stator on the ANO-1 turbine deck resulted in substantial damage to turbine building structural members and to the turbine deck floor itself in the vicinity of the impact. The 4160 VAC switchgear A1 and A2 located immediately below where the stator impacted the turbine deck were damaged, rendering offsite power sources from startup #1 and startup #2 transformers inoperable. The 4160 VAC supply to ANO-1 from Alternate AC Current (Black) Diesel Generator also was damaged.

Falling components impacted the north wall of the train bay causing structural damage, rupturing an 8" fire main and a 2½" hose reel supply resulting in substantial fire water spray into the train bay area. The stator came to rest against the south wall of the train bay on top of the transport vehicle. Both the north and south non-structural concrete masonry unit walls of the train bay suffered substantial damage.

The shock caused by the temporary lift assembly failure and the stator falling was detected by seismic Sensor XR-8007 located on the Unit 1 Spent Fuel Pool Deck (Elev. 404') in the Auxiliary Building. The horizontal pseudo cumulative absolute velocity calculated by Sensor XR-8007 was 0.01242g in the north-south direction and 0.02263g in the east-west direction. Both of these values are well below the 0.05g threshold for anticipated vibration-induced damage. The other five seismic monitors installed at the station were functioning and did not experience vibration above their recording triggers. There are two design basis earthquakes for ANO: 0.1g Operating Basis Earthquake (OBE) and 0.2g Safe Shutdown Earthquake (SSE). Based on the calculated results, there is no indication that vibrations exceeding 0.1g OBE occurred.

The shock from the stator contacting the turbine building, and temporary lift assembly components falling into the turbine building, caused relays in the ANO-2 switchgear area located just adjacent to the train bay to actuate resulting in the trip of 2P-32B reactor coolant pump. This, in turn, resulted in a trip to the Unit 2 reactor (CR-ANO-2-2013-00583). The ANO-2 post-trip response was normal with the exception that the position indication for 2CV-0748 Feedwater Loop A Main Feedwater Regulating Valve showed the valve to be 7.7% open, when in fact the valve had closed as designed (CR-ANO-2-2013-00823). In response to this indication, the operators tripped the main feedwater pumps and manually initiated Emergency Feedwater.

The loss of offsite power to ANO-1 resulted in the automatic start and tie into their respective safety buses of both emergency diesel generators. Service water pumps automatically started and restored header pressure as designed. The ANO-1 operators restored decay heat removal in a timely manner in accordance with OP-1203.028, *Loss of Decay Heat Removal.* The protected red train was placed in service first, with P34A Decay Heat Removal (DHR) pump started at 0754 and DHR flow initiated at 0756. As a backup to P34A, P34B DHR pump was started at 0805 with its DHR flow path established at 0806. There are no bulk temperature readings available for the fuel transfer canal; however, during this period the E35A decay heat outlet temperature increased from an approximate steady state temperature of 77°F to approximately 85°F.

Response to loss of spent fuel pool cooling was performed in accordance with Abnormal Operating Procedure OP-1203.050, *Unit 1 Spent Fuel Pool Emergencies.* Spent Fuel Pool (SFP) cooling flow was re-established at 0813 when P40B SFP Cooling Pump was started. Intermediate Cooling Water flow was momentarily established at approximately 0930, after an offsite power source had been connected and established for longer-term operation

approximately one hour later at 1030. From 0750 to 1043, spent fuel pool temperature rose approximately 2.8°F from 87.0°F to a peak of 89.8°F (design temperature of the spent fuel pool is 200°F).

Immediate attempts were made by Operations personnel to isolate fire water spraying from the broken fire water piping into the train bay area. A field operator was dispatched to shut down the fire water pumps in the ANO-1 intake structure. Power to the electric fire pump was lost due to damage to the A-1 switchgear. The field operator did not immediately recognize a temporary electric motor-driven fire water pump was in service at this time supplying water to the header (CR-ANO-C-2013-01072). The temporary fire water pump was subsequently secured. Spray from the fire water piping rupture, migrated into the ANO-2 switchgear area. The fire water that had pooled on the floor in the switchgear area entered the 2A1 switchgear at the location of the 2A-113 breaker cubicle causing an electrical fault at approximately 0923 on the 2A-1 4160V supply bus from start-up transformer #3 (SU3). This fault resulted in a protective relaying lockout of SU3 which tripped all SU3 feeder and load breakers (CR-ANO-2-2013-00565). Switchgear 2A-2 was deenergized following the SU3 lockout resulting in a loss of offsite power to 2A-2 and 2A-4. The 2K-4B emergency diesel generator started as designed and supplied safety bus 2A-4. Start-up transformer #2 (SU2) feed to 2A-2 breaker 2A-211 was in pull-to-lock per OP-2107.001 *Electrical System Operation*, (normal configuration). Switchgear 2A-1 successfully slow transferred its feed to SU2 and provided power to 2A-1 and safety bus 2A-3. Switchgear 2A-1 remained energized throughout the event. Figure 1 depicts the ANO-2 high voltage distribution system.

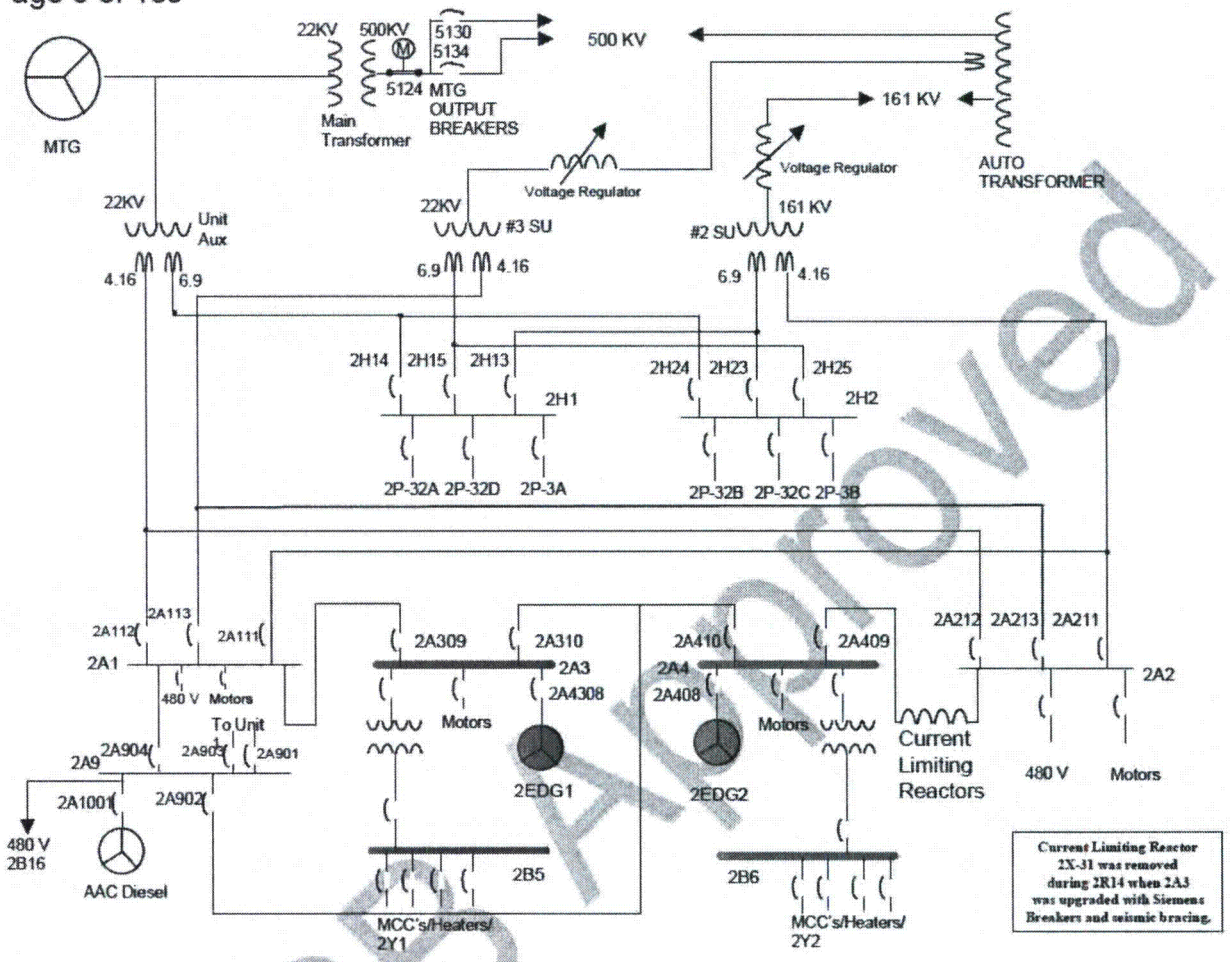


Figure 1. ANO-2 High Voltage Distribution System

Loss of SU3 6900V buses 2H-1 and 2H-2 caused the loss of power to the two running Reactor Coolant Pumps (RCP) and the one running circulating water pump. Accordingly, the plant operators commenced a natural circulation cooldown using the atmospheric dump valves.

The loss of bus 2-A2 resulted in a loss of power to one of two instrument air compressors and the slow transfer to SU2 resulted in the loss of the second instrument air compressor, which in combination with loss of both ANO-1 instrument air compressors, caused the instrument air header which was cross-tied between the units to depressurize, complicating the ANO-2 response.

A Notification of Unusual Event (NUE) was declared at 1033, based on EAL HU-4, fire or explosion, following confirmation that the lockout of SU3 was due to an electrical fault in the switchgear at breaker 2A-113 with indications reported of bus damage.

The operator response to the event was effective with actions taken to maintain the plants in a safe and stable condition despite the challenges associated with the lift assembly failure, medical response for injured personnel, and the challenges associated with degraded power condition. Safety systems performed as designed, aiding the operators in the event recovery. Appropriate actions were taken on both units to respond to the condition created by the stator drop. The station's response ensured satisfaction of Entergy's obligation to protect public health and safety.

An assessment of the ANO-1 Operations Response to the Event is contained in Exhibit 2a. An assessment of ANO-1 Equipment Response on 3/31/2013 is contained in Exhibit 2b. An assessment of Unit 2 Operations response to the event is contained in Exhibit 3.

Scope

The scope of this Root Cause Evaluation (RCE) is to evaluate the cause of the temporary lift assembly failure and the consequences from a personnel safety and equipment damage perspective. Two firms were included in the RCE team to provide their independent subject matter expertise. [redacted] performed evidence collection and structural analysis. [redacted] evaluated the organizational and programmatic controls associated with human performance and industrial safety.

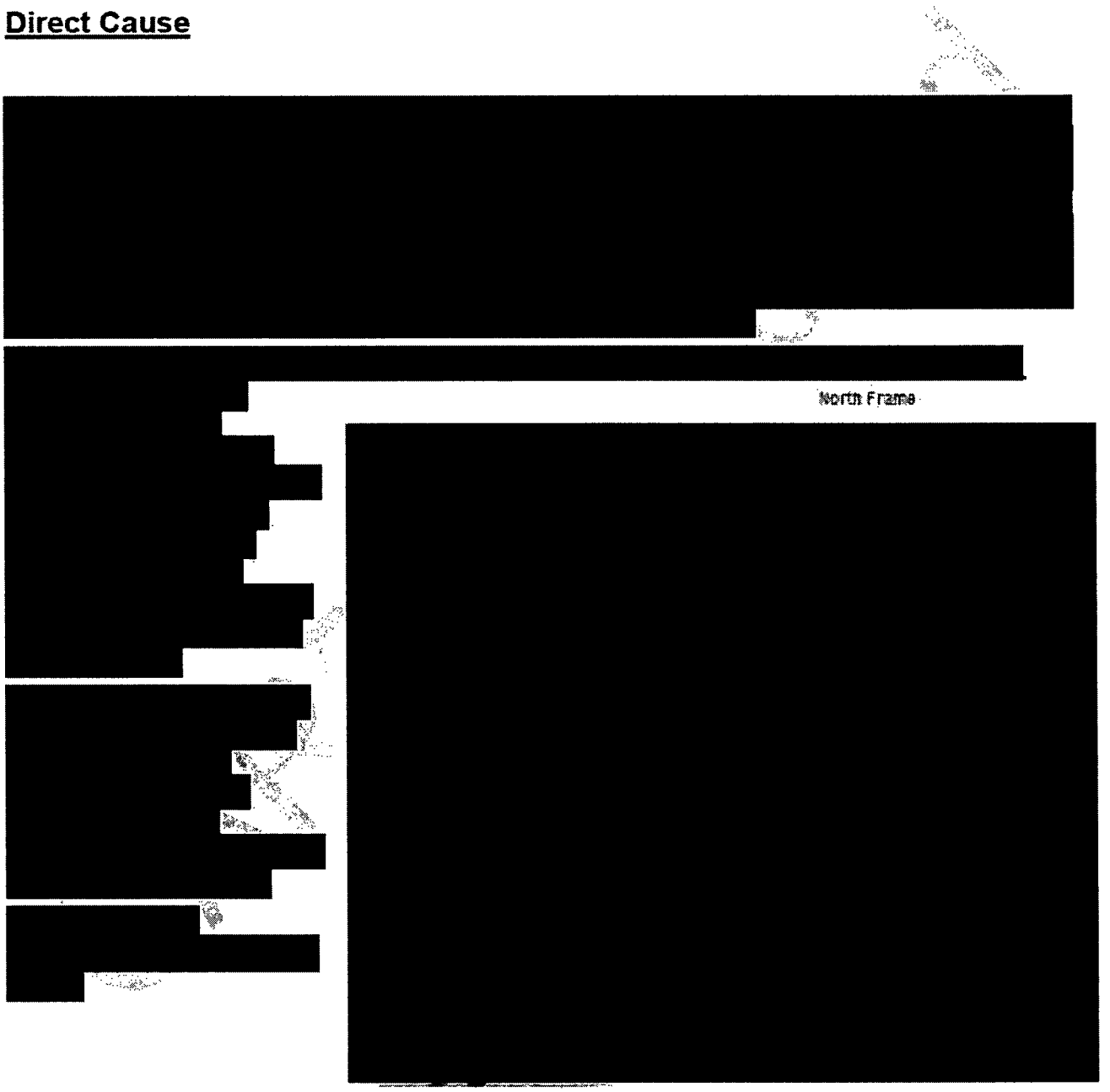
Additional condition reports closed to this RCE and how the CRs are addressed are identified in Attachment 7 – CRs Closed to CR-ANO-C-2013-00888

The purpose of this RCE is to establish corrective actions to assure that conditions that led to the temporary lift assembly failure are promptly identified and corrected and that measures necessary to prevent recurrence are identified and implemented.

Access restrictions by the stator contractor, Siemens, and its heavy lift subcontractor, Bigge, limited the ability of the Root Cause Team to further assess underlying causes. Had the Root Cause Team had full access to material, personnel and records related to the event, it appears likely that additional contributing causes may have been developed. Attachment 8 identifies some of the topics that would have been explored if access to the information and personnel were made available. Nonetheless, the information available was more than adequate to identify why the event occurred and to identify corrective actions Entergy can take to protect personnel and equipment.

Root Cause Evaluation

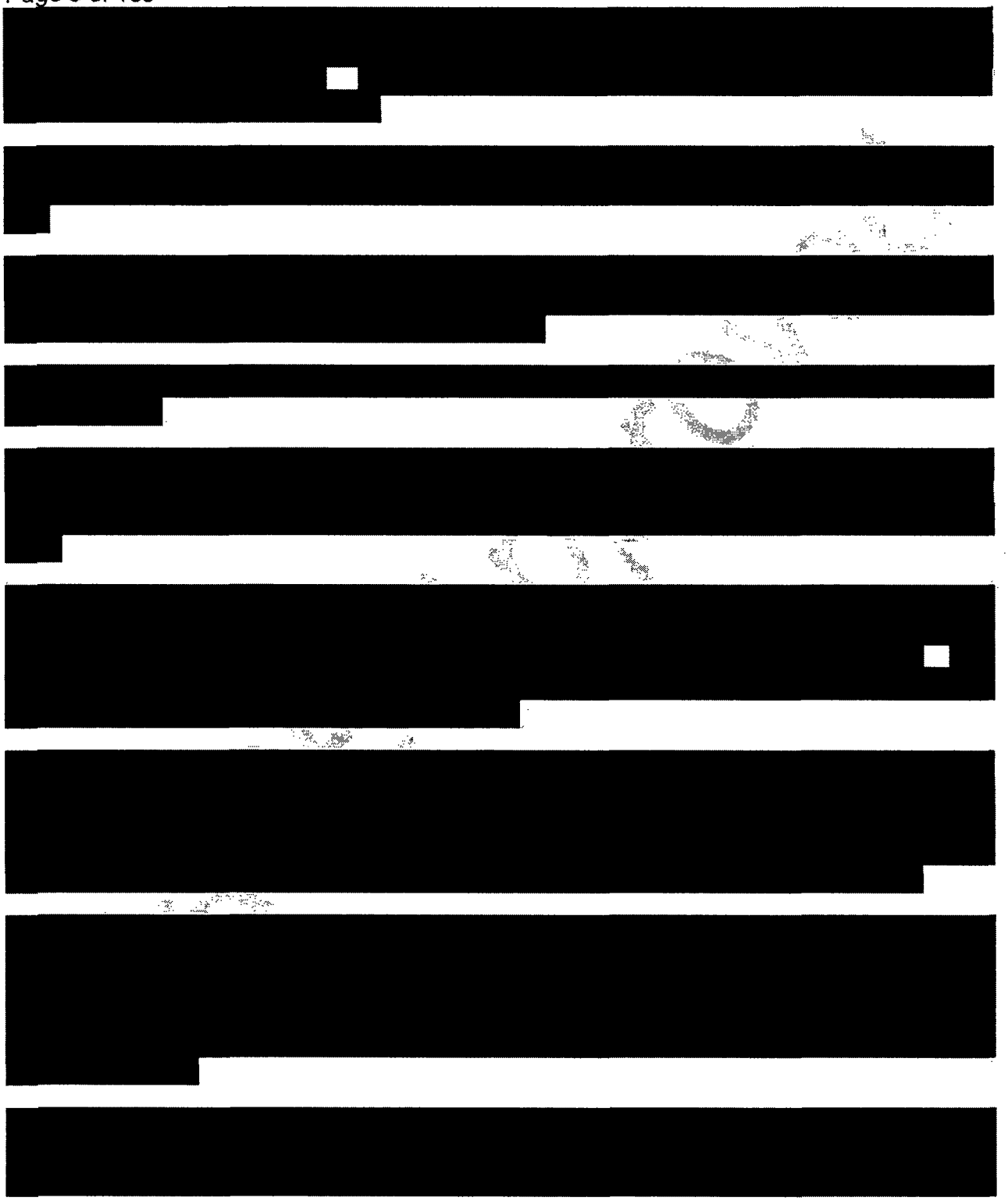
Direct Cause

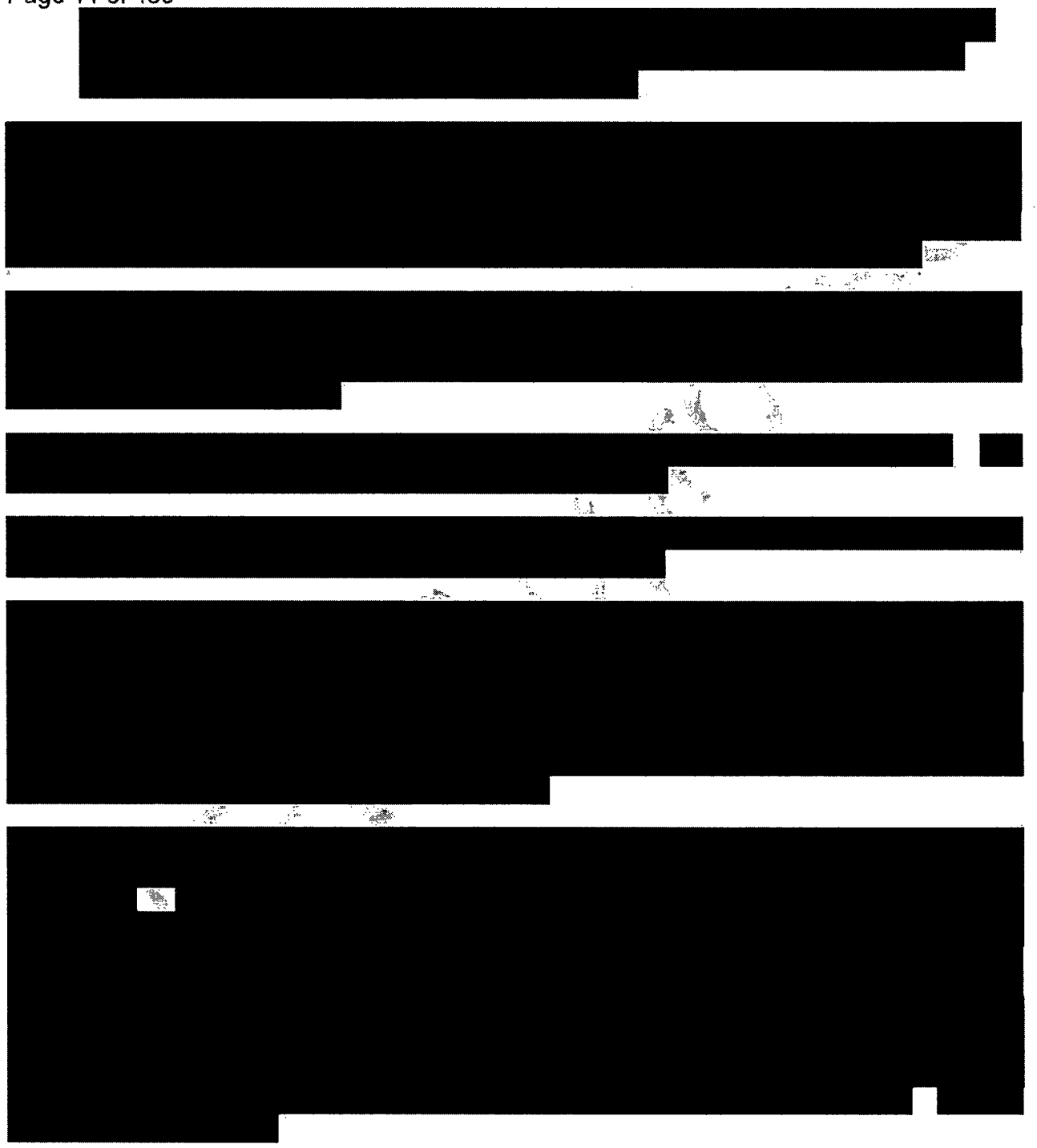


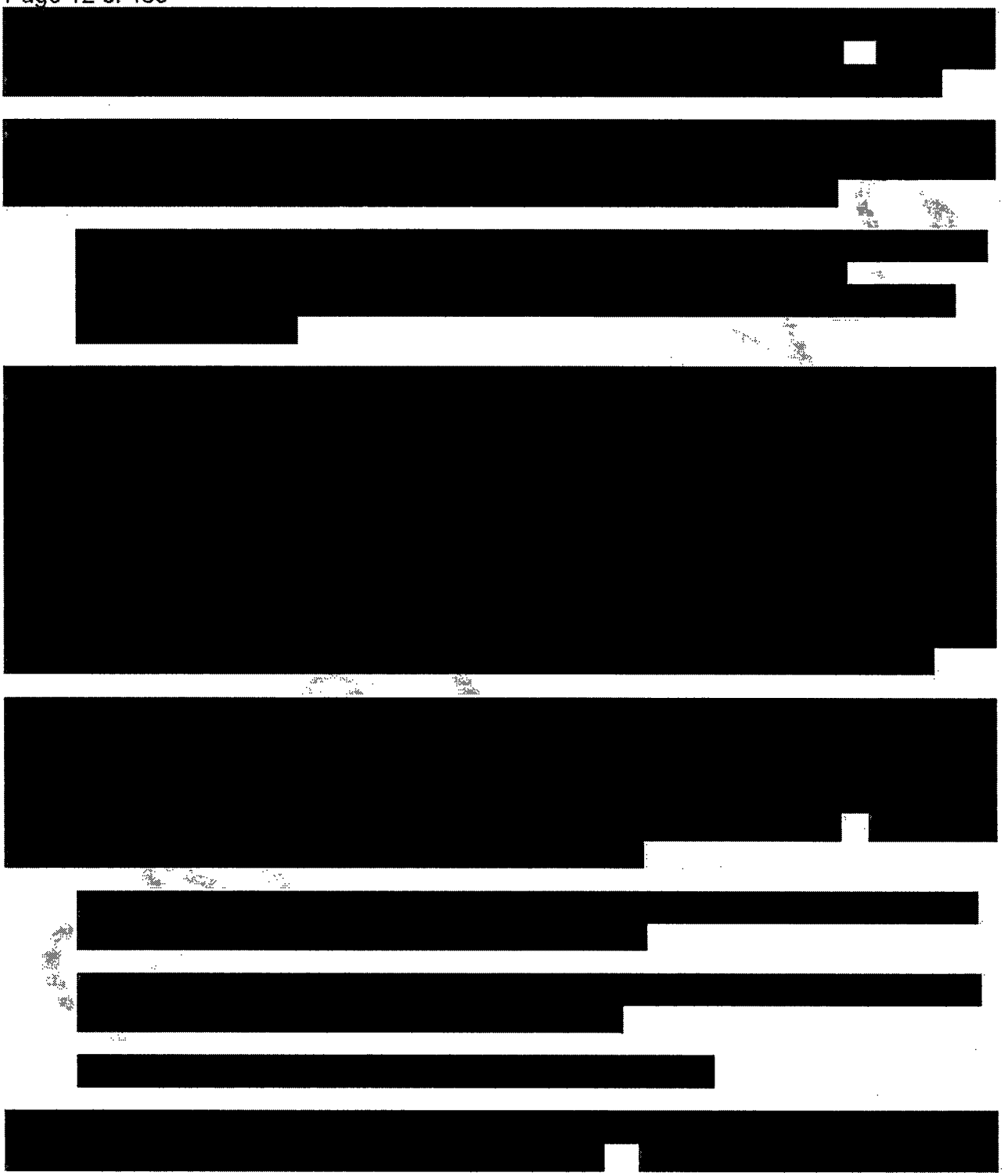
[redacted]

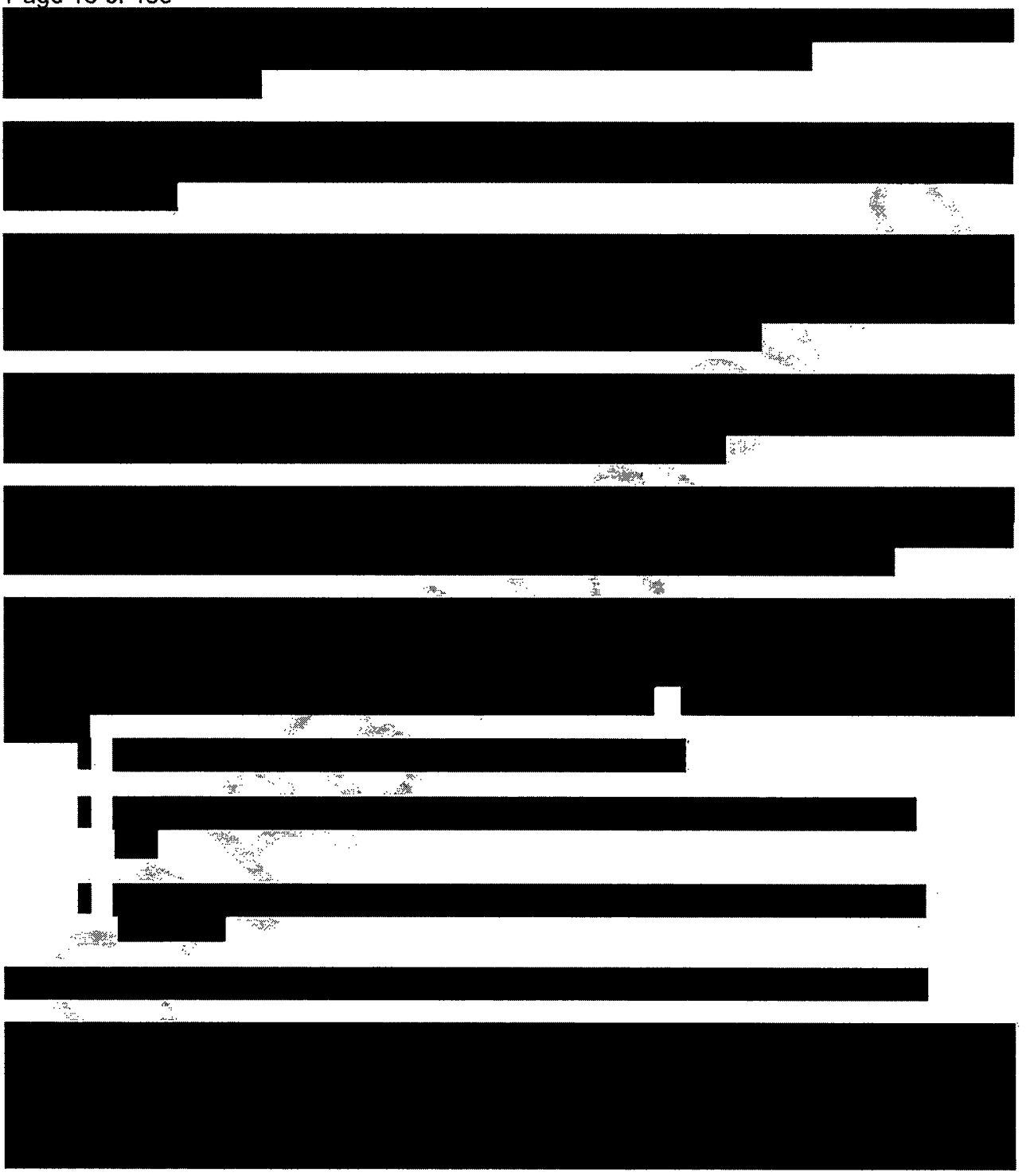
Event Scenario

[redacted]









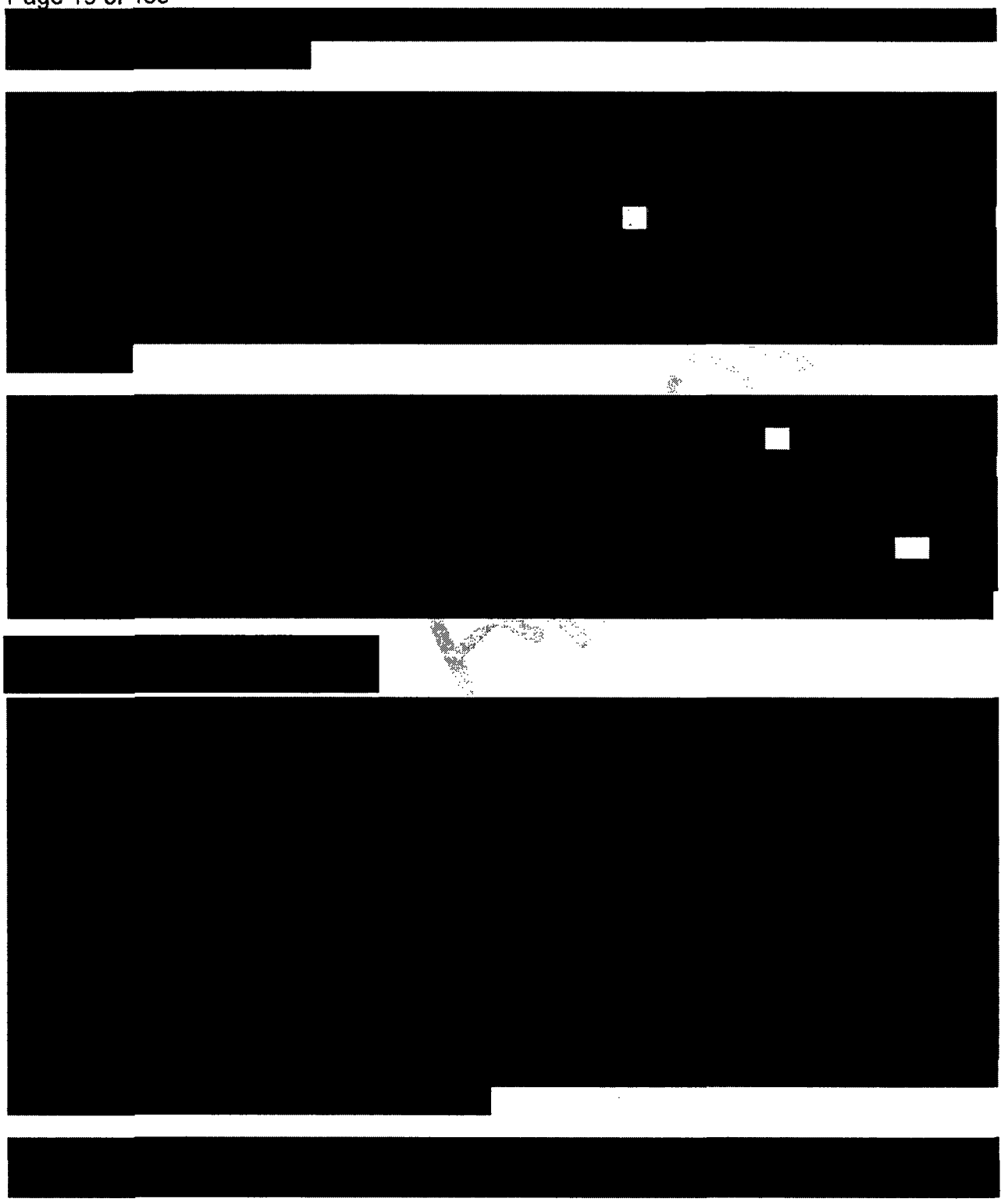
[redacted]

Analysis

[redacted]

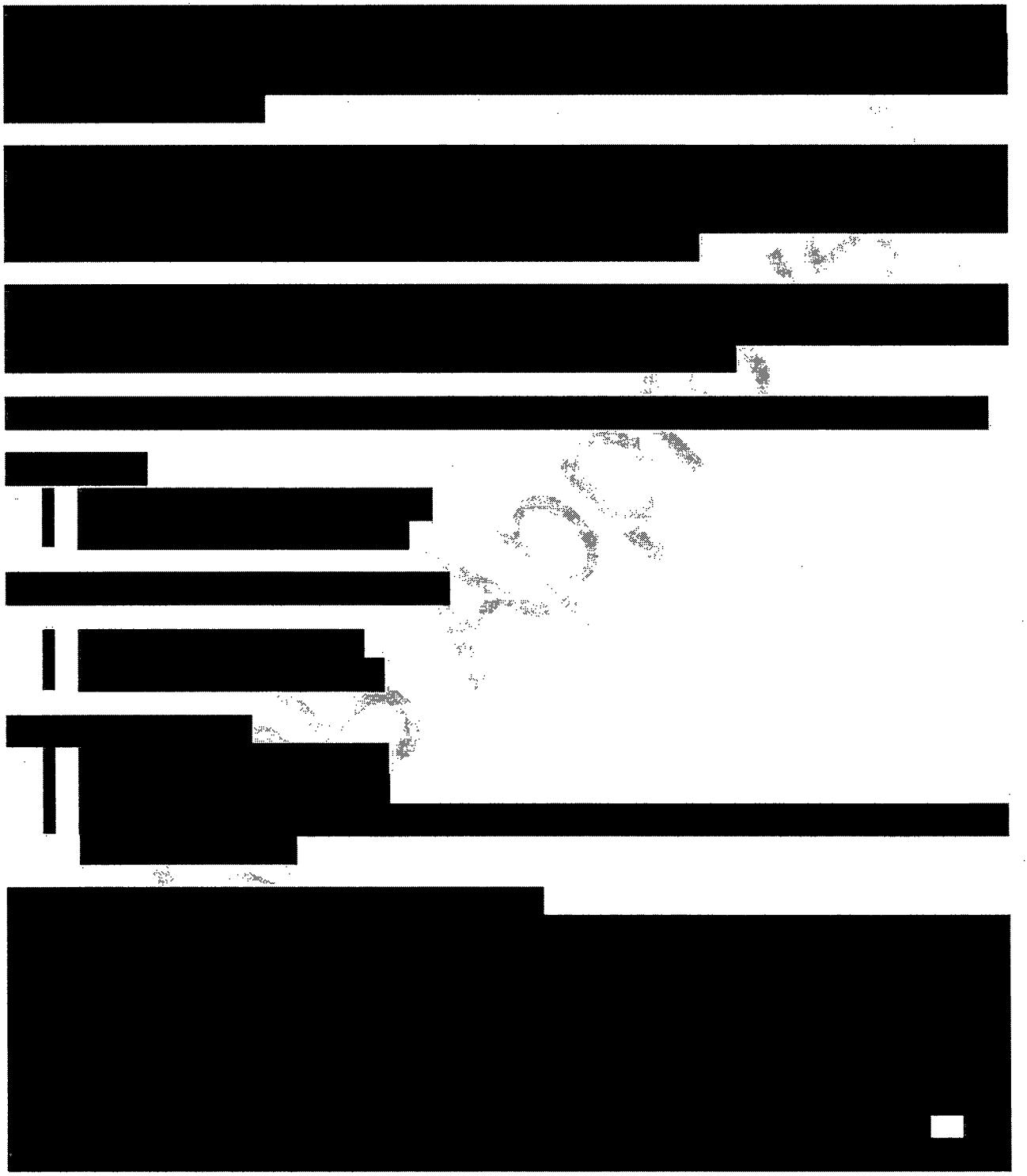
[redacted]

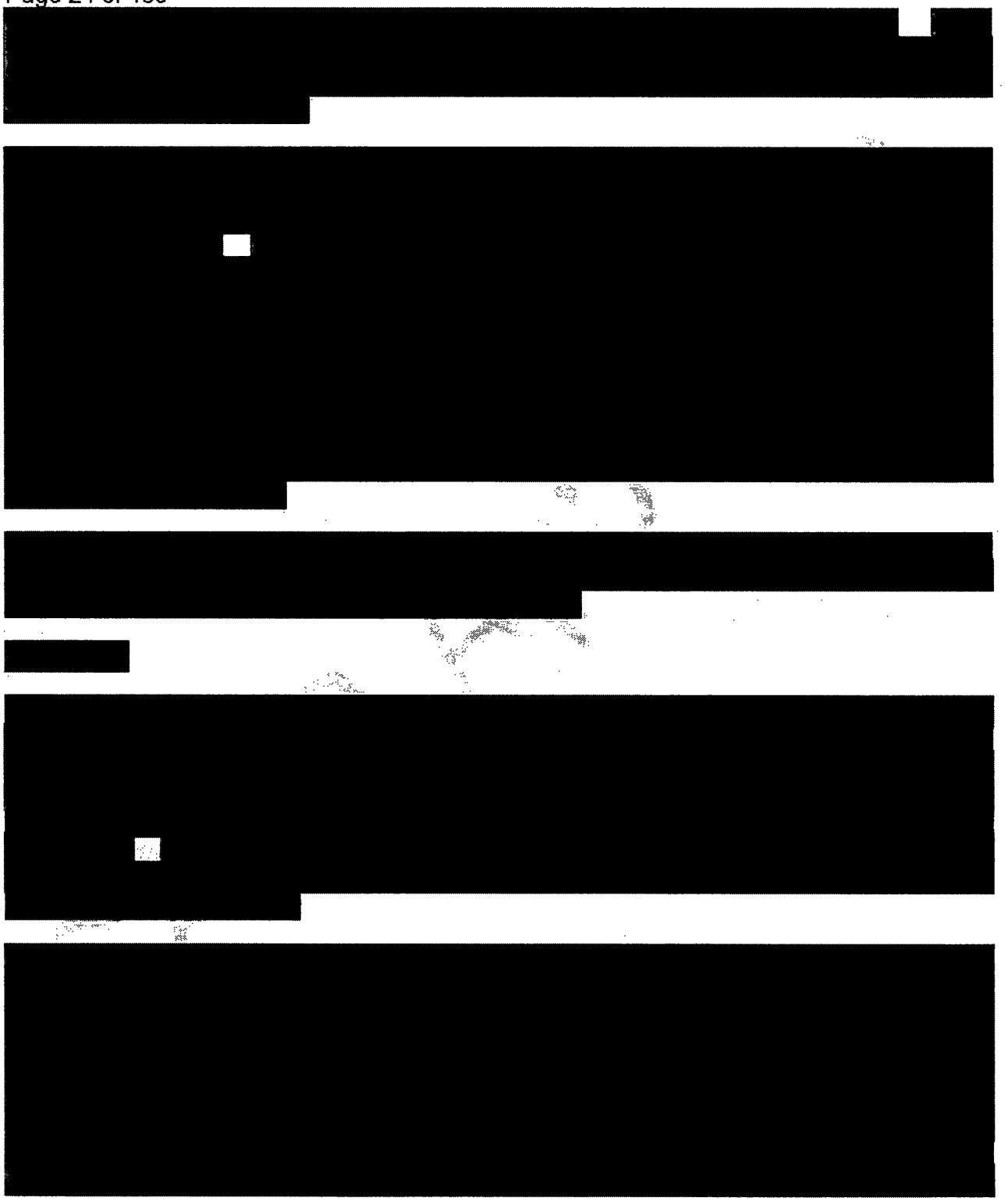
[redacted]



[redacted]

[redacted]





[redacted]

Root Causes:

Direct Cause is defined as:
The action or condition that occurs immediately prior to the consequential event that is being investigated; may be considered as the "trigger" for the event.

DC1 - The direct cause of the temporary lift assembly collapse was buckling of the northwest lower column.

Root Cause is defined as:
The most basic cause(s) for a failure or a condition that, if corrected or eliminated, will preclude repetition of the event or condition.

RC1 - The root cause of the temporary lift assembly collapse is that the Bigge design did not ensure the lift assembly north tower could support the loads anticipated for the lift. DC1C - Design analysis deficiency

[redacted]

RC2- Bigge failed to perform required load testing of their modified temporary lift assembly prior to its use at ANO in accordance with OSHA regulation. MT1E – Testing not performed as required

[redacted]

Contributing Causes:

Contributing Cause is defined as:
An identified cause that if corrected would not by itself have prevented the event. This type of cause may have facilitated *the event's occurrence, increased its severity, or lengthened the time to discovery.*

CC1 – Siemens and Bigge inaccurately represented that the hoist assembly had been used at other electric power stations to lift components that exceed the anticipated weight of the unit 1 stator. [redacted]

[redacted]

[redacted]

CC2 – Siemens failed to provide adequate oversight and control of Bigge's performance

- [redacted]
- [redacted]
- [redacted]
- [redacted]

CC3 – EN-MA-119 does not provide clear guidance regarding independent reviews of special lift equipment. [redacted]

- [redacted]
- [redacted]
- [redacted]

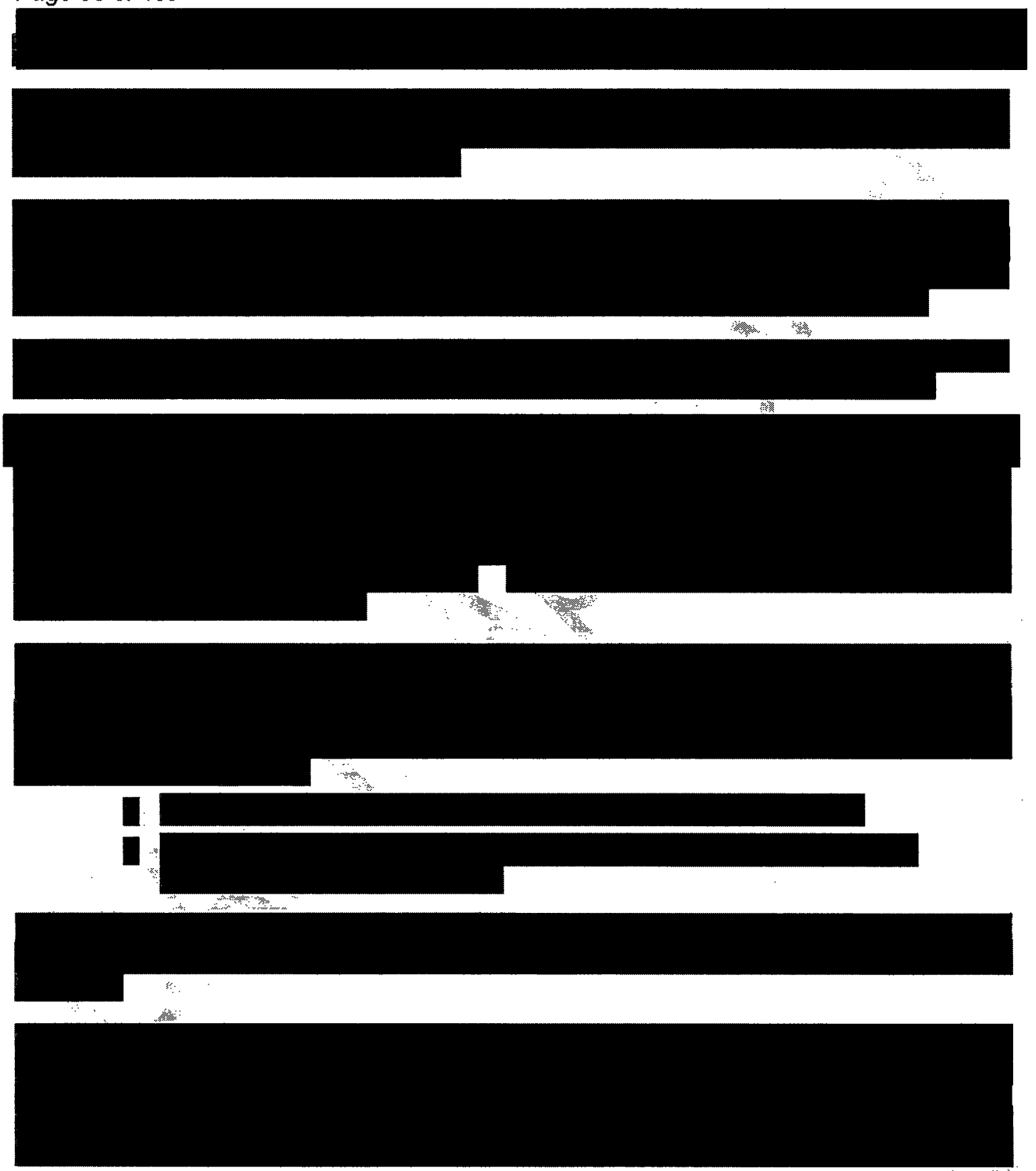
CC4 – Supplemental Project personnel lacked sufficient knowledge of OSHA and ASME NQA-1 application to temporary lift assemblies and accepted Bigge's assertion that load testing was not required based on a combination of engineering analysis and previous use. [redacted]

- [redacted]

[redacted]

Organizational and Programmatic Weakness Evaluation

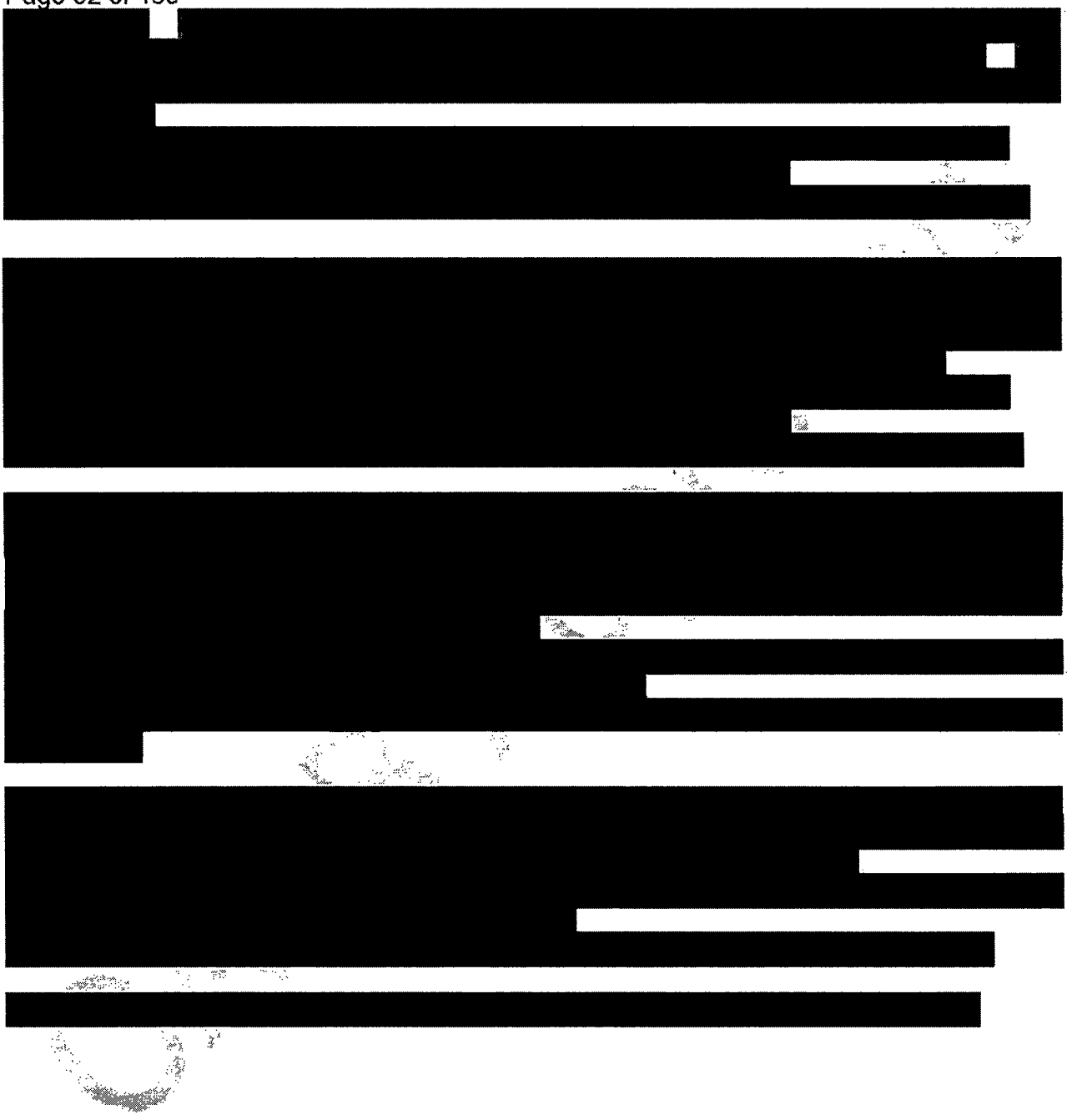
[redacted]



[redacted]

Safety Culture Evaluation (provide summary):

[redacted]



Generic Implications: Extent of Condition and Extent of Cause

Extent of Problem/Condition:

[redacted]

Extent of Cause:

[redacted]

[redacted]

[redacted]

Previous Occurrence Evaluation

[redacted]

Policies and Procedures

[redacted]

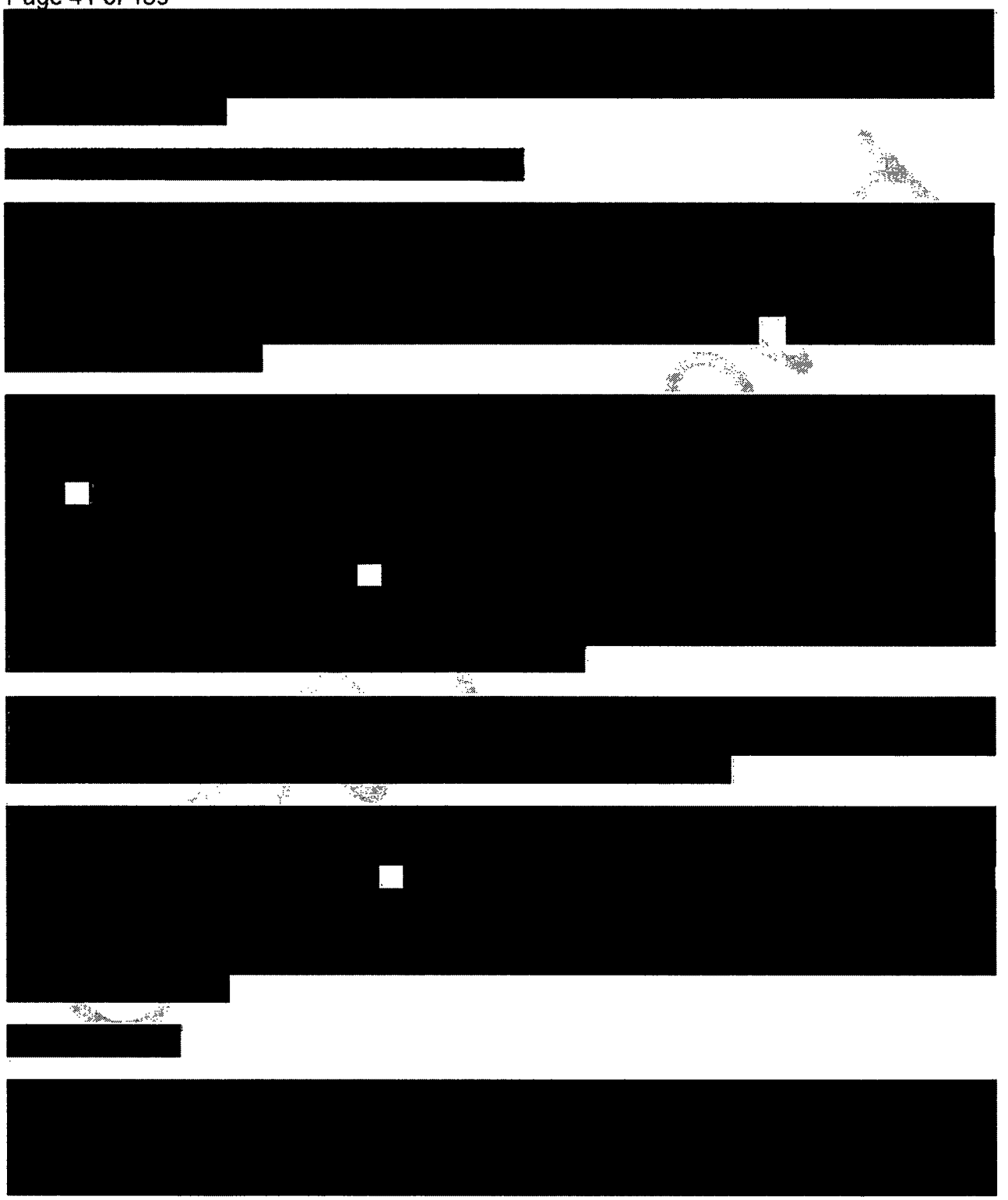
[redacted]

OE Conclusions

[redacted]

Safety Significance Evaluation

[redacted]



[redacted]

[redacted]

[redacted]

[redacted]

Corrective Action Plan

All root and contributing causes, and generic implications must have corrective actions or a documented basis why no action is recommended.

Identified Cause	Corrective Actions	Responsible Dept.	Due Date
	Immediate Actions		
	Interim Actions		
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Identified Cause	Corrective Actions	Responsible Dept.	Due Date
	[redacted]		

[redacted]

Identified Cause	Corrective Actions	Responsible Dept.	Due Date
	Short & Long Term Actions		
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Identified Cause	Corrective Actions	Responsible Dept.	Due Date
[redacted]			

[redacted]

Identified Cause	Corrective Actions	Responsible Dept.	Due Date
[redacted]			

[redacted]

Identified Cause	Corrective Actions	Responsible Dept.	Due Date
	[redacted]		
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Identified Cause	Corrective Actions	Responsible Dept.	Due Date
[redacted]	[redacted]	[redacted]	[redacted]

Effectiveness Review Plan

This section should contain an Effectiveness Review strategy that includes the following:

Method – Describe the method that will be used to verify that the actions taken had the desired outcome.

Attributes – Describe the process attributes to be monitored or evaluated.

Success – Establish the acceptance criteria for the attributes to be monitored or evaluated.

Timeliness – Define the optimum time to perform the effectiveness review.

1. Effectiveness review actions are required for all CAPRs.

CAPR:1 [redacted]			
	DESCRIPTION		
Method:	[redacted]		
Attributes:	[redacted]		
Success:	[redacted]		
Timeliness:	[redacted]		
Owner Group:	Projects	**Due Date:**	[redacted]

CAPR:2 [redacted]	
	DESCRIPTION
Method:	[redacted]

[redacted]

Attributes:	[redacted]		
Success:	[redacted]		
Timeliness:	[redacted]		
Owner Group:	Projects	**Due Date:**	[redacted]

- **Repeat the above for each CAPR, as required.**
- **Similar MAST criteria may also be shown for other important corrective actions.**

TREND DATA (coordinate entry in the PCRS Trend Table of this CR):

Cause Codes:

Human Performance Causal Factor(s) (List all): [redacted]

O&P Causal Factor(s) (List all): [redacted]

Equipment Causal Factors (List all): [redacted]

EFE Codes:

INPO ER PO&C Codes: [redacted]

Failure Mode Codes: [redacted]

Safety Culture Evaluation Codes:

NSC-NRC Codes (List all): [redacted]

NSC-INPO Codes (List all): [redacted]

Other Trends Codes

Operator Fundamental Keywords (List all): None

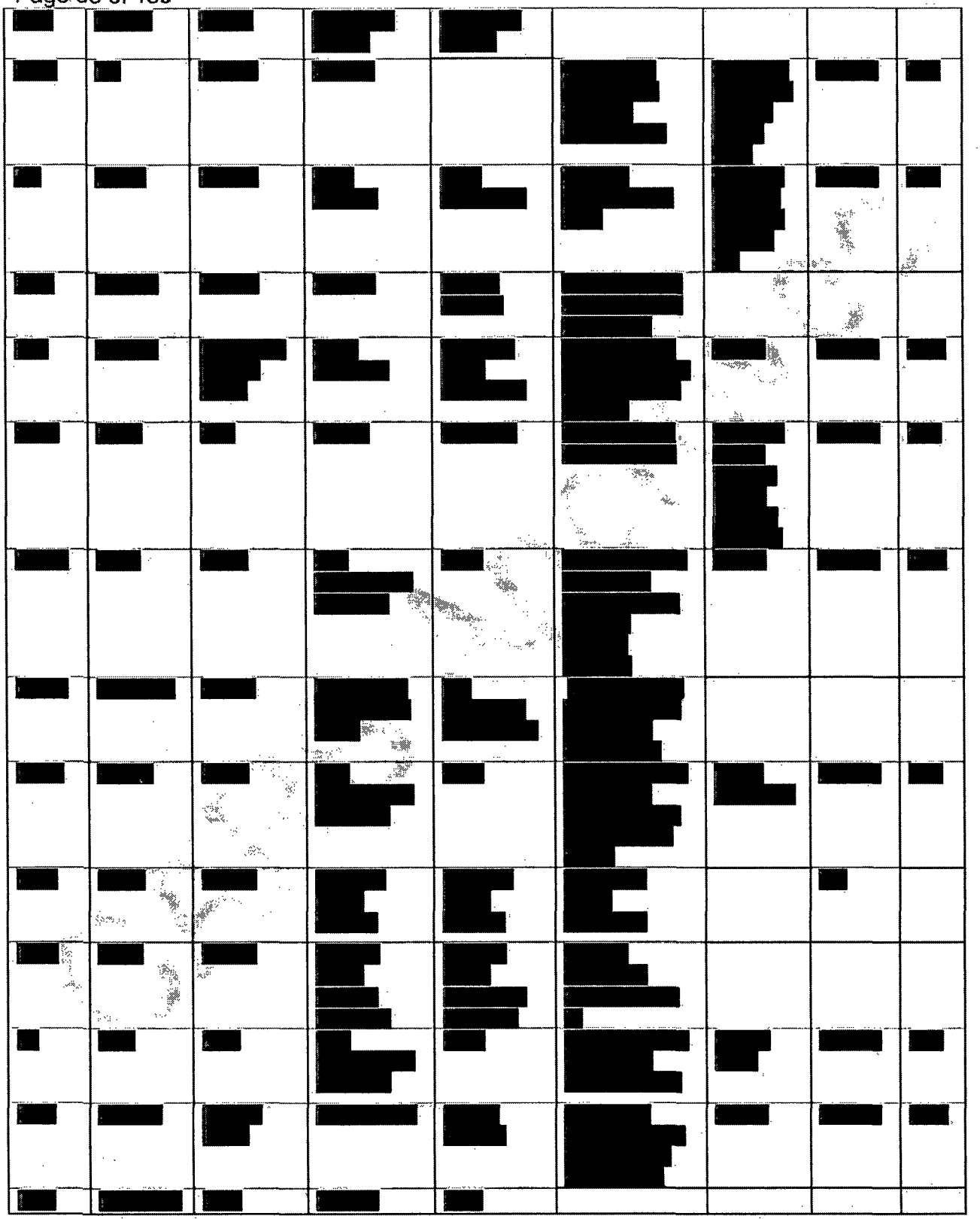
References

Documents Reviewed

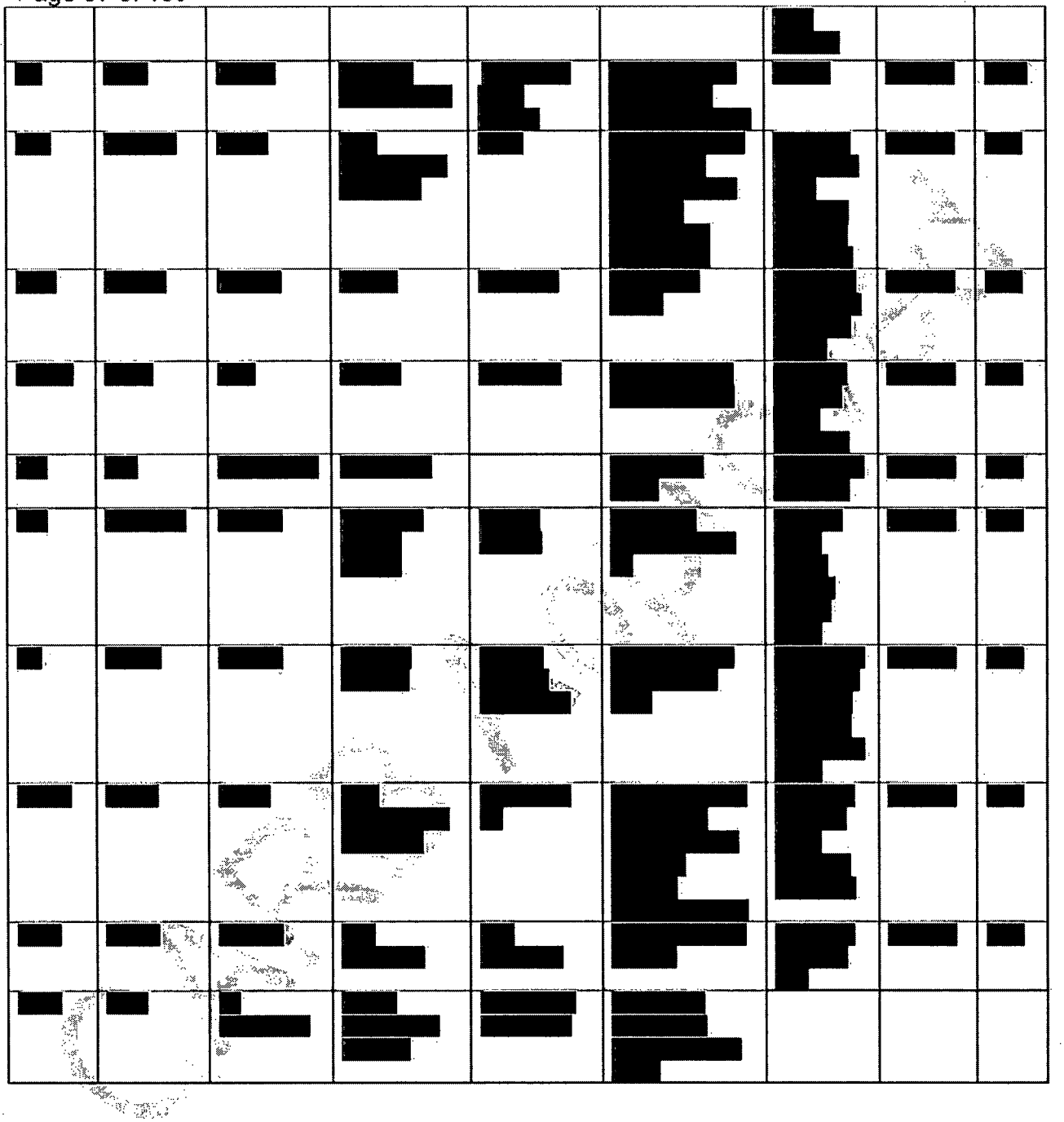
Refer to Documents Listed in Comparative Timeline.

Personnel Contacted

First Name	Last Name	Company	Position	Title	Responsibilities	Location During Event	Interview Date	Shift
[redacted]								



[redacted]



[redacted]

Team Members

Name	Title	Company
[redacted]	[redacted]	[redacted]

Exhibits

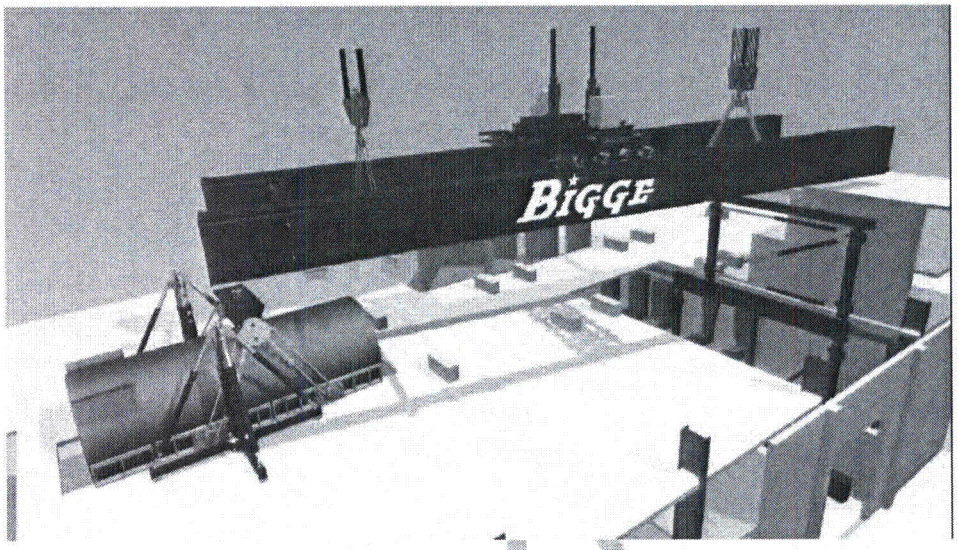
Exhibit 1	Intended Lift Process
Exhibit 2a	Assessment of ANO-1 Operator Response on 3/31/2013
Exhibit 2b	Assessment of ANO-1 Equipment Response on 3/31/2013
Exhibit 3	ANO Unit 2 Impacts
Exhibit 4	Code Requirements
Exhibit 5	Bigge Gantry Crane Tower System Failure Contingency Plan

Analysis Methods Used

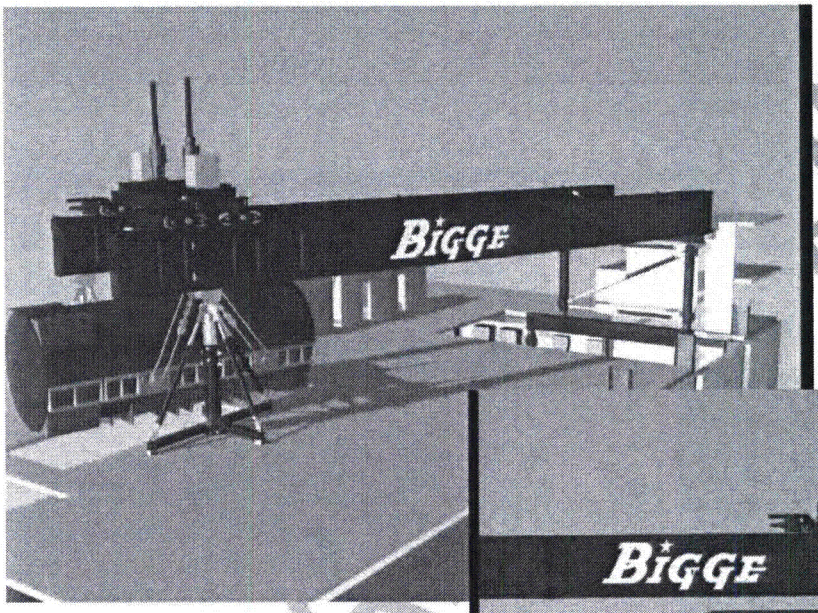
Attachment 1	Fault Tree
Attachment 2	Events and Causal Factors Chart
Attachment 3a	[redacted] Structural Evaluation Status Report
Attachment 3b	Failure Modes Analysis
Attachment 4	Comparative Timeline
Attachment 5	Evaluation for Organizational and Programmatic Issues
Attachment 6	Safety Culture
Attachment 7	CRs Closed to CR-ANO-C-2013-00888
Attachment 8	Acknowledgement of limitations
Attachment 9	Operating Experience Review

[redacted]

The swap of the Unit 1 stator was planned to follow the following basic flow.

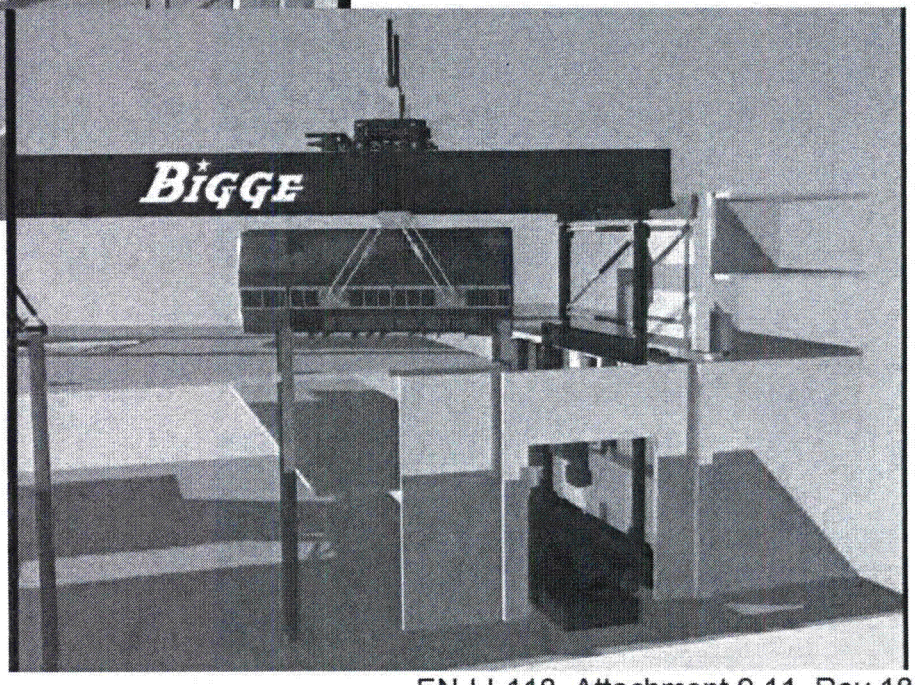


A portable gantry system is assembled between the Unit 1 stator and the train bay. Stations are placed at the south end of the gantry system. A tower is assembled at the north end of the gantry system in the train bay.



The Unit 1 stator is lifted. The procedure requires that the load is monitored to ensure there is not an overload due to binding or unexpected weight. The load is level to within specifications.

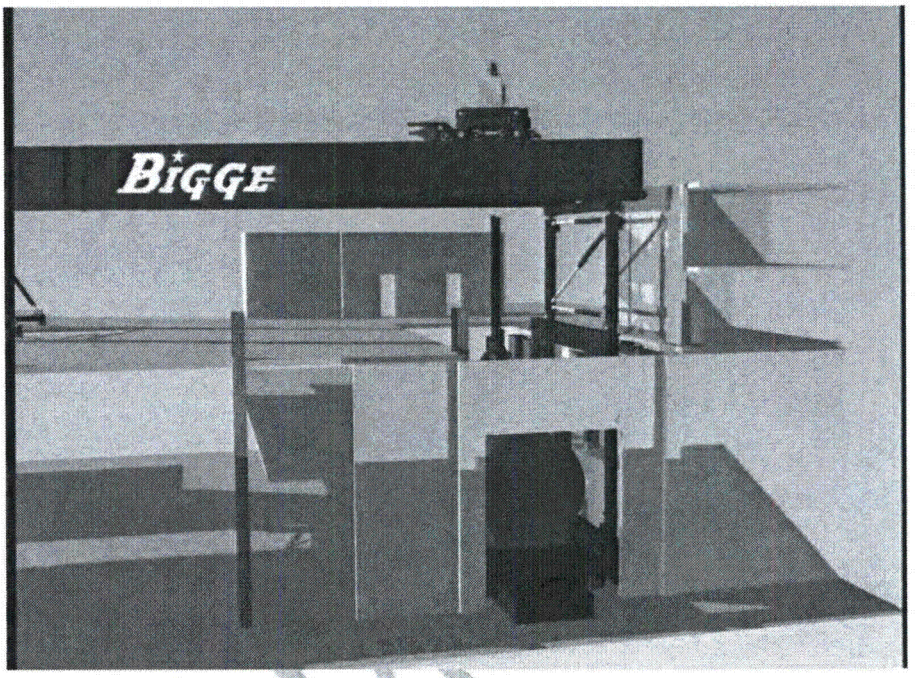
The load is then transported to the train bay and rotated to lower into the bay.

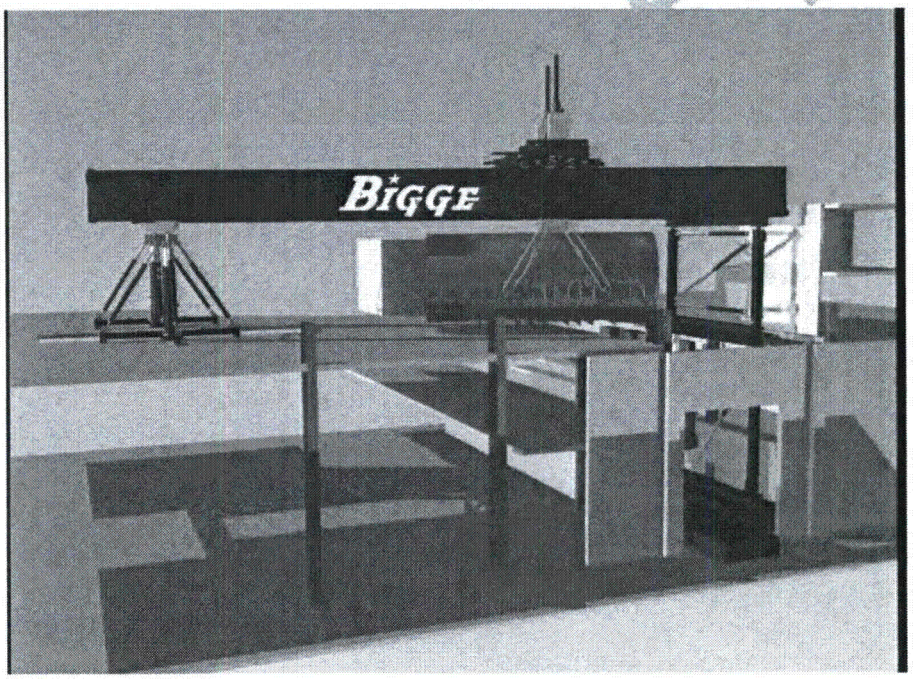


A Goldhofer transport is located in the train bay to receive the stator.

The stator is rotated to align with the train bay.

The stator is lowered on to the Goldhofer. Scaffolding is built to gain access to remove the rigging. Once the rigging is removed, the stator is then removed from the train bay. The modernized stator is brought into the train bay and the process is reversed to return the modernized stator to the stator pedestal.





[redacted]

Exhibit 2a - **Assessment of ANO-1 Operator Response on 3/31/2013**

Summary Assessment of Crew Performance

The Unit 1 operating crew effectively responded to the event on 3/31/13 with the following key results:

- Decay Hear Removal (DHR) function was restored within five minutes
- Spent Fuel Pool (SFP) cooling function was restore in a timely manner with less than 3°F rise in SFP temperature
- Emergency medical response was initiated in a timely manner and effectively coordinated

Crew response was aided by the presence of additional licensed personnel who were in the control room as planned for support of the refueling outage. These operators assisted with the medical emergency procedure, ERO interface, station log maintenance, etc.

The Shift Manager remained in his oversight role and exercised his responsibility throughout the event. He appropriately used the team, including ERO and outage support personnel, to respond to the event. The CRS maintained command and control and used transient briefs throughout the day to maintain priorities and alignment.

Key Actions and Related Procedures

1. Restoration of Decay Heat Removal per OP-1203.028, *Loss of Decay Heat Removal*

   Decay Heat Removal function was restored in accordance with (IAW) Section 6.0 of OP-1203.028, *Decay Heat Pump Trip*. The protected red train was placed in service first with P34A DHR pump started at 07:53:51 and DHR flow initiated at 07:55:49.

   As a backup to P34A, P34B DHR pump was started at 08:05:17 with DHR flow established at 08:06:10.

   The order for containment closure was initiated by the Shift Manager and appropriately rescinded after DHR was restored.

   DHR was established in a timely, controlled manner IAW the Abnormal Operating Procedure with no anomalies noted.

2. Response for Loss of Offsite Power Source to 4160V Electrical Buses per EOP-1202.007, *Degraded Power.*

   Proper automatic system response was verified per EOP-1202.007. This included verifying EDG operation per Repetitive Task 21, verifying cooling flow to the EDGs, verifying auto-start of Service Water pumps, and aligning feeder breakers to non-vital switchgear in Pull-to-Lock status.

At the time of the event, electrical alignments were in progress to support planned activities for the Green Train maintenance window of 1R24. These resulted in the following initial conditions:

a. A2 4160 V bus was de-energized

b. A3 and A4 4160 V buses were initially cross-tied

c. B5 and B6 480 V buses were cross-tied

d. D06 Green Train battery had been disconnected from D02 bus

e. D04B battery charger was supplied from Swing MCC B56 to provide power to Green Train DC bus D02 during the Green Train outage. B56 was aligned to B5 at the time of the event.

Following the event, actions were taken to restore normal electrical alignment. These included re-connecting the green train battery and restoring normal alignment for B5 and B6 vital 480V buses. The cross-tie between A3 and A4 switchgear automatically separated on an undervoltage signal.

Response to loss of offsite power was performed in a timely, controlled manner IAW the applicable procedures with no anomalies noted in operator performance.

3. Response to loss of spent fuel pool cooling per AOP-1203.050, *Loss of Spent Fuel Pool Cooling*

Response to loss of SFP cooling was performed IAW AOP-1203.050. Spent fuel pool cooling flow was re-established at 0813 when P40B SFP Cooling Pump was started. Intermediate Cooling Water Flow was momentarily established at approximately 0930 after an offsite power source had been connected and established for longer term operation approximately one hour later at 1030. From 0749 to 1043, Spent Fuel Pool temperature rose approximately 2.8°F from 87.0°F to a peak of 89.8°F.

Power to P33C ICW pump was restored via a planned Temporary Modification that provided power from an offsite source unrelated to the A1 and A2 4160V Switchgear damaged in the event.

The delay between 0930 and 1030 in restoring ICW flow was the result of variation in ICW surge tank levels observed when P33C was initially started. This was attributed to repositioning of ICW Suction and Discharge cross-connect valves on loss of Instrument Air. The crew chose to maintain the ICW pump idle until the two ICW loops could be cross-connected at both the suction and discharge headers for the ICW pumps. This configuration was established within approximately one hour and long term SFP cooling capability was then restored.

The planned temporary alteration providing diverse power to the ICW pumps proved very useful in restoring Spent Fuel Pool cooling. SFP cooling was

established in a timely and controlled manner with less than 3°F rise in SFP temperature.

4. Fire Water Leak

   When the fire water leak was reported to the control room, the Shift Manager and CRS appropriately decided to depressurize the fire water system. Operators were dispatched to the Intake Structure to secure the fire water pumps locally. While at the intake the operator successfully secured the diesel driven fire water pump but later recognize the temporary motor driven fire water pump being supplied power from the London line was in operation. The temporary fire water pump was secured at approximately 0820 hours (CR-ANO-C-2013-01072 was initiated to assess the timeliness of securing the temporary fire pump). The action to secure fire water was appropriate for conditions and compensatory actions were promptly initiated to stage portable fire water pumps and obtain assistance from the London Fire department. Technical Requirements Manual (TRM) requirements for the fire suppression system were appropriately considered.

   During the event the "At-the-Controls" (ATC) operator observed "Dirty Waste Panel Trouble" alarm K09-F5 had alarmed and that the Auxiliary Building Sump level was high. The Waste Control Operator (WCO) was dispatched to elevation 317' and water was observed to be accumulating in the general area. The WCO inspected the Decay Vaults and observed no accumulation of water at that time. The WCO had previously verified that the DH vault doors were dog closed and the DH vault drain isolation valves ABS-13 and ABS-14 were closed. Water level in the general area on elevation 317' reached approximately 1.5" and stopped rising as the fire water pumps had been stopped. Later a comparable water level was observed to have accumulated in the 'B' DHR vault. Components in the DHR vault were not challenged by the accumulation of water; however, this condition did indicate probable leakage through vault isolation valve ABS-13. Water level in the 'B' DHR vault was not sufficient to actuate the level switch associated with K09-D4, Train B Decay Heat Room Flood, which has an actuation setpoint of approximately 1.6 inches (CR-ANO-1-2013-00824 and CR-ANO-C-2013-01129).

5. Response to Loss of Instrument Air per AOP-1203.024, *Loss of Instrument Air*

   The majority of actions dictated by the Loss of Instrument Air AOP were not applicable for the conditions present at the time of this event. Consequences of the loss of Instrument air included:

   a. DHR Cooler Bypass Valves CV-1432 and CV-1433 failed closed
   b. Pneumatic DHR pump suction temperature indications failed low
   c. ICW pump cross-connect valves failed closed.

Failure of the DHR cooler bypass valves was anticipated by the Control Room staff. The 'A' DHR train was aligned with the cooler bypass valve fully closed prior to the loss of instrument.

For ICW cooling, the 'C' ICW pump had been selected for operation. Consequently, a flow path for the Nuclear ICW loop existed when Instrument Air was lost.

6. Emergency Classification per OP-1903.010, *Emergency Action Level Classification*

   Criteria for Emergency Action Level classification were reviewed by the Shift Manager and peer checked by other Senior Reactor Operators present in the Control Room. No applicable criteria were identified.

7. Emergency Response/Notifications per OP-1903.011, *Emergency Response/Notifications*

   The Shift Manager elected to staff the ANO Emergency Response Organization based on the complexity of the event. ERO staffing was initiated via voice message IAW OP-1903.011.

   A courtesy call to the Arkansas Department of Health and NRC Operations Center was performed IAW OP-1903.011 for this event of Potential Public Interest.

8. Response to Injuries per OP-1903.023 *Personnel Emergency*

   Emergency medical team was dispatched and ambulances were promptly requested IAW the instructions of form OP-1903.023B.

9. Response to Loss of Control Room Phones and Plant Computer Network

   Normal phone service was lost momentarily during the event. Using instructions provided with the Station Blackout procedure tab, analog phones were placed in service and verified functional within a matter of minutes.

   An extra Reactor Operator was assigned responsibility for the station log. When computer network problems affected access to the station log application, a paper log was maintained and later transferred to the electronic log.

[redacted]

Exhibit 2b - **Assessment of ANO-1 Equipment Response on 3/31/2013**

Summary Assessment of Plant Equipment Response

The event had the following significant, direct impacts to plant equipment:

- 4160 VAC Switchgear A1 and A2 were damaged, rendering offsite power sources from Startup #1 and Startup #2 Transformers inoperable
- 4160 VAC supply from AACDG via 2A9 Switchgear was damaged and rendered inoperable
- Firewater lines in the train bay were severed, requiring that fire water pumps be secured
- Instrument Air header pressure was lost when shared source from Unit 2 degraded due to the loss of 2A2.
- Key safety systems functioned as designed with the following highlights:
  - Both Emergency Diesel Generators automatically started and tied to their respective bus
  - Service Water pumps automatically started and restored header pressure as designed
  - Both trains of DHR responded as designed when placed back in service

Equipment necessary to support Spent Fuel Pool cooling operated as necessary to restore SFP cooling with less than 3°F rise in SFP temperature.

Sealing pressure to the nozzle dams on the lower Steam Generator manways slowly lowered after power was lost to associated support equipment. Compensatory actions were taken to provide an alternate means of pressurizing the seals. (CR-ANO-1-2013-00830).

Water ingress was noted in the vault for the B train of DHR equipment indicating probable leakage through the associated drain isolation valve (CR-ANO-1-2013-00825). Water did not leak into the vault for the A train of DHR.

System Level Review

1. Electrical System

At the time of the event, electrical alignments were in progress to support planned activities for the Green Train maintenance window of 1R24. These resulted in the following initial conditions:

- A2 4160 V bus was de-energized
- A3 and A4 4160 V buses were initially cross-tied

- B5 and B6 480 V buses were cross-tied
- D06 Green Train battery had been disconnected from D02 bus
- D04B battery charger was supplied from Swing MCC B56 to provide power to Green Train DC bus D02 during the green train outage. B56 was aligned to B5 at the time of the event.

Review of the accident video and comparison of timing between Unit 1 Loss of Power and Unit 2 Reactor Trip suggests that A1 Bus locked out early in the accident sequence, perhaps when the stator first impacted the turbine deck.

After A1 locked out, EDG #1 properly started and achieved rated voltage and frequency within 15 seconds. On the other hand, starting of EDG #2 was delayed as no DC power was present for associated relaying and control components. This was expected for the configuration with D06 battery disconnected for replacement. Once power was restored to DC bus D02 via charger D04B, EDG #2 started and provided power to associated components.

2. Service Water

   Service Water components functioned as designed with no anomalies noted.

3. Decay Heat System

   DHR components functioned as designed with one minor anomaly noted. A few hours after initiation of the event, the Low Pressure Injection flow indicator for Loop A DHR/LPI failed low. (CR-ANO-1-2013-00830)

4. Steam Generator Nozzle Dams

   As documented in CR-ANO-1-2013-00830, sealing pressure for the Steam Generator nozzle dams slowly lowered after loss of power to support equipment. Compensatory actions were taken to provide an alternate means of maintaining sealing gas pressure.

5. Spent Fuel Pool Cooling and Intermediate Cooling Water

   Spent Fuel Cooling Pumps, which are powered from vital buses B5 or B6, functioned as designed. Intermediate Cooling Water was restored through use of a planned Temporary Modification which provided power from an unaffected off-site source. P33C was selected as the pump to receive temporary power due to its association with the Nuclear ICW loop.

   During restoration of Intermediate Cooling Water, variation in ICW surge tank levels was noted when P33C ICW pump was initially started in Single Loop, Single Pump

mode of operation (cross-connect valves closed due to loss of Instrument Air). This indicated possible leak by associated cross-connect valves (CR-ANO-1-2013-00912). Once Instrument Air pressure was restored and ICW loops were cross-tied, stable surge tank level was observed.

6. Auxiliary Building

   Leakage into the Auxiliary Building was noted as documented in CR-ANO-1-2013-00824. No adverse equipment consequences were noted as result of this leakage. Additionally, leakage into the 'B' Decay Heat Vault was noted as documented in CR-ANO-1-2013-00825, indicating probable leakage past vault drain isolation valve ABS-13.

7. Components Supported by Instrument Air

   When Instrument Air pressure was lost, components responded as expected. Noteworthy impacts included:

   a. DHR Cooler Bypass valves failed closed
   b. ICW Pump Cross-Tie Valves Failed Closed
   c. Pneumatic DHR Pump Suction Temperature indicators failed low.

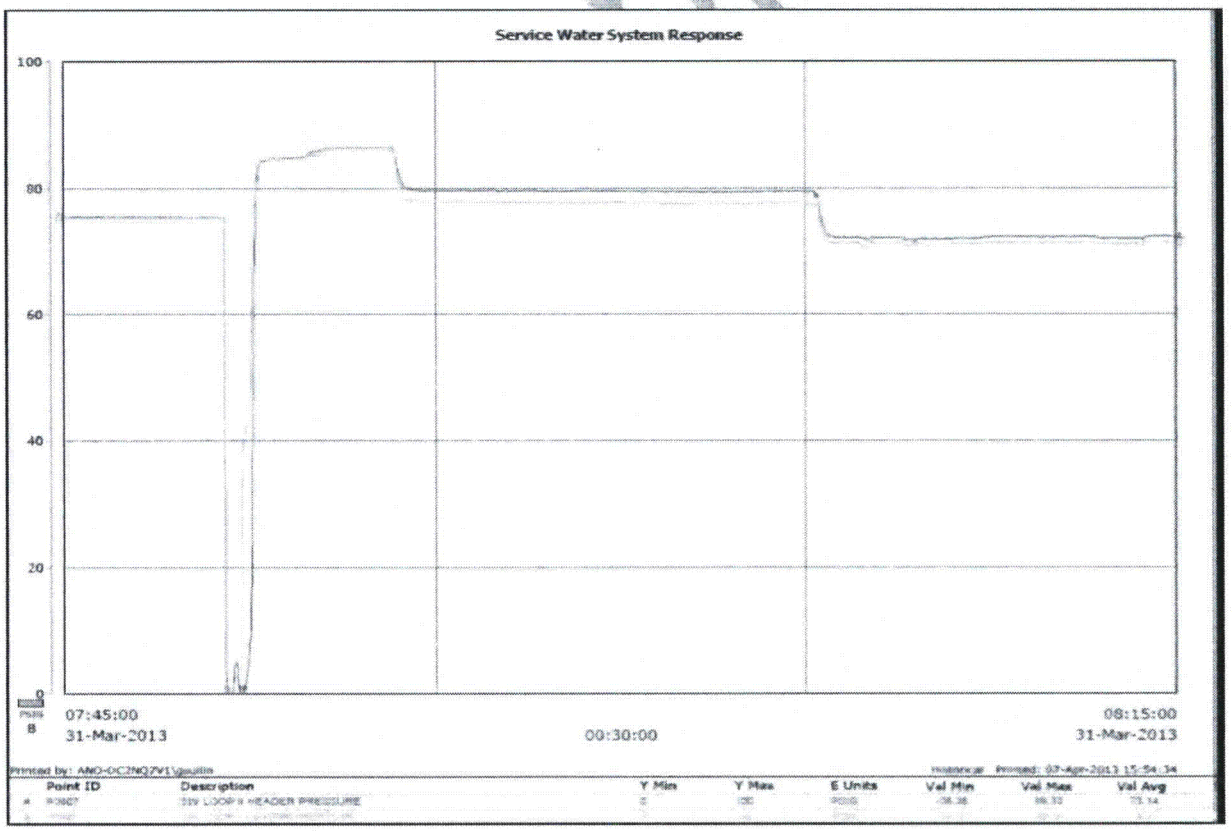


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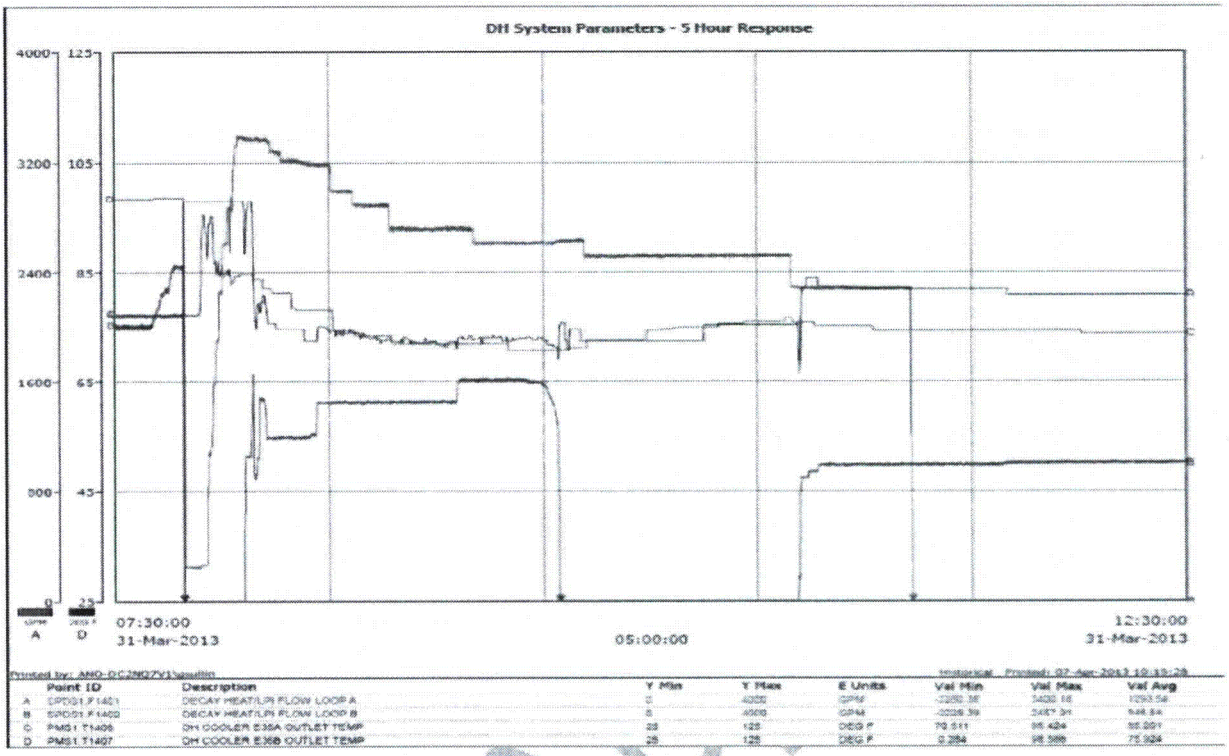
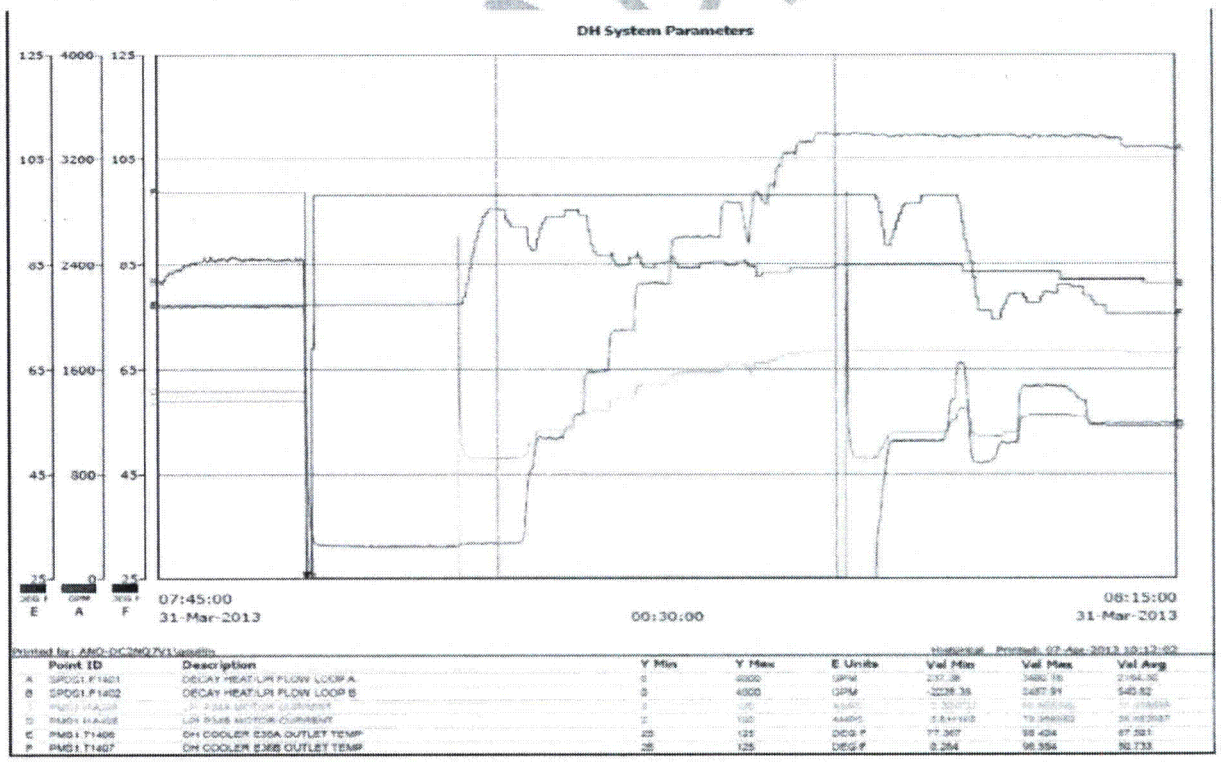
Exhibit 2b - **Assessment of ANO-1 Equipment Response on 3/31/2013**



	Point ID	Description	Y Min	Y Max	E Units	Val Min	Val Max	Val Avg
A	SPDG1.F1401	DECAY HEAT/LPI FLOW LOOP A	0	4000	GPM	-3280.38	3480.16	1293.58
B	SPDG1.F1402	DECAY HEAT/LPI FLOW LOOP B	0	4000	GPM	-3208.39	3487.91	945.82
C	PMS1.T1406	DH COOLER E36A OUTLET TEMP	23	125	DEG F	79.511	95.424	86.297
D	PMS1.T1407	DH COOLER E36B OUTLET TEMP	25	125	DEG F	0.264	98.586	75.924



	Point ID	Description	Y Min	Y Max	E Units	Val Min	Val Max	Val Avg
A	SPDG1.F1401	DECAY HEAT/LPI FLOW LOOP A	0	4000	GPM	-3280.38	3480.16	1293.58
B	SPDG1.F1402	DECAY HEAT/LPI FLOW LOOP B	0	4000	GPM	-3208.39	3487.91	945.82
C	PMS1.T1406	DH COOLER E36A OUTLET TEMP	23	125	DEG F	79.511	95.424	87.391
F	PMS1.T1407	DH COOLER E36B OUTLET TEMP	25	125	DEG F	0.264	98.586	76.733

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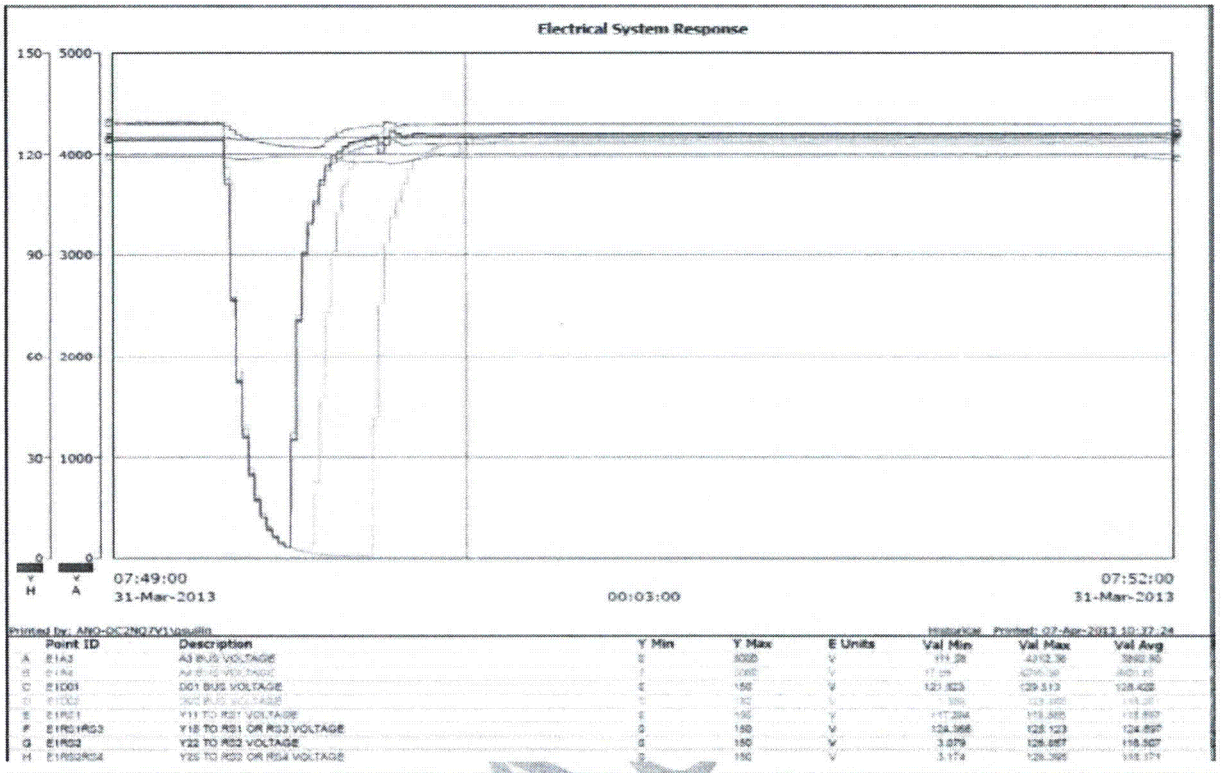
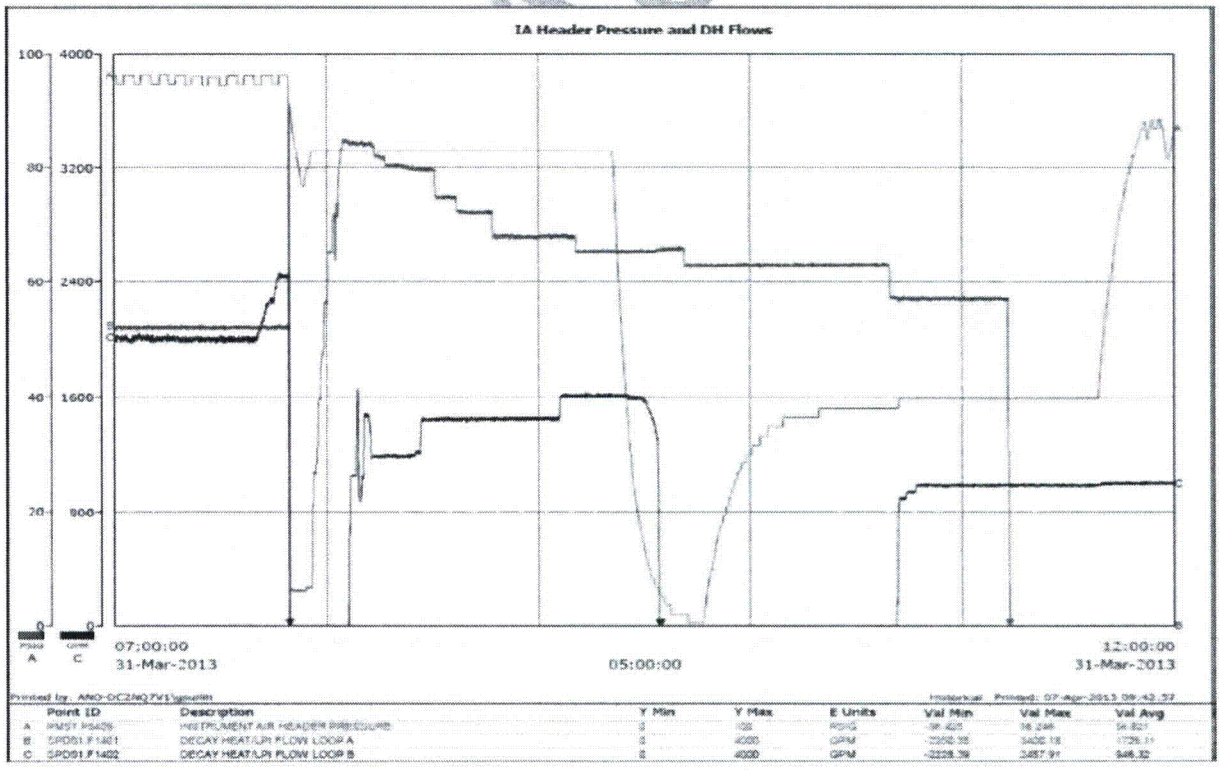
Exhibit 2b - **Assessment of ANO-1 Equipment Response on 3/31/2013**



	Point ID	Description	Y Min	Y Max	E Units	Val Min	Val Max	Val Avg
A	E1A3	A3 BUS VOLTAGE	0	5000	V	111.28	4312.36	3992.90
B	E1A4	A4 BUS VOLTAGE	0	5000	V	47.26	4245.30	4001.65
C	E1D01	D01 BUS VOLTAGE	0	150	V	121.823	129.513	128.402
D	E1D02	D02 BUS VOLTAGE	0	150	V	0.000	123.695	118.287
E	E1R21	Y11 TO R21 VOLTAGE	0	150	V	117.204	118.895	118.897
F	E1RS1RS3	Y18 TO RS1 OR RS3 VOLTAGE	0	150	V	124.368	128.123	124.897
G	E1RS2	Y22 TO RS2 VOLTAGE	0	150	V	3.079	126.087	118.307
H	E1RS2RS4	Y25 TO RS2 OR RS4 VOLTAGE	0	150	V	3.174	126.395	118.171



	Point ID	Description	Y Min	Y Max	E Units	Val Min	Val Max	Val Avg
A	PMST P5405	INSTRUMENT AIR HEADER PRESSURE	0	100	PSIG	98.405	98.246	98.827
B	SPD01F1401	DECAY HEAT/LPI FLOW LOOP A	0	4000	GPM	3000.55	3406.18	1726.11
C	SPD01F1402	DECAY HEAT/LPI FLOW LOOP B	0	4000	GPM	2208.39	3487.91	846.30

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Exhibit 2b - **Assessment of ANO-1 Equipment Response on 3/31/2013**

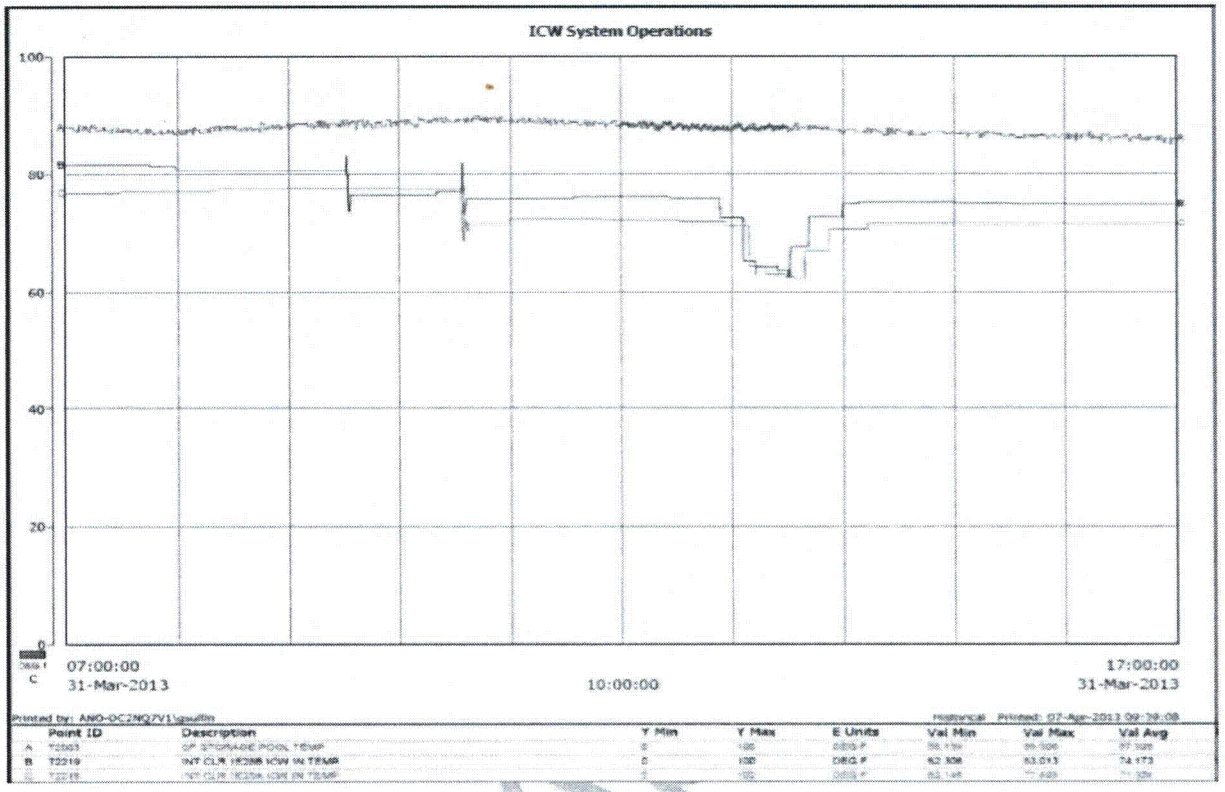

Exhibit 3 - **ANO Unit 2 Impacts**

This assessment was performed to evaluate the ANO-2 response to the U1 stator drop event on 3/31/13. This event was a challenge to the operators and was successfully navigated without major issues identified in the operations team performance. A summary of the emergency/abnormal procedures implemented during the event and recovery include:

- Standard Post Trip Actions
- Reactor Trip Recovery
- Loss of Instrument Air
- Personnel Emergency
- Fire Water Main Rupture response
- Spent Fuel Pool Emergencies
- Emergency Plan
- Fire and Explosion
- Natural Circulation

The following provides a list of the major challenges and activities that were present throughout the day. This assessment starts at the time of the U2 plant trip and extends through the end of shift brief (1830). Each of the following items are addressed in further detail in CR-ANO-2-2013-00903 CA-1.

- U2 reactor trip due to 'B' RCP breaker tripping on motor differential relay (vibration) as a result of the stator impact to the U2 turbine building structure.
- Fire water turbine building main ruptured in the train bay
- Personnel Emergency procedure entered
- Standard post trip actions (SPTA) implemented and compensatory actions taken for 'A' Main Feedwater Regulating Valve (MFRV) Failure. Running Main Feedwater Pump (MFP) tripped and Emergency Feedwater Actuation System (EFAS) actuated.
- Response to fire water spraying on plant equipment
- Control Room (CR) isolation due to rad monitor (RI-8001) actuation – manually placed CR on emergency recirculation
- Secured 2P-7A and 2P-7B Emergency Feedwater (EFW) Pumps (T.S. 3.0.3 entry) to support placing Auxiliary Feedwater (AFW) Pump in service

Exhibit 3 - **ANO Unit 2 Impacts**

- Reset EFAS and restored 2P-7B to standby. Remained in T.S. 3.7.1.2 for throttling EFW injection motor operated valves (MOVs) using AFW
- SU#3 Lock out due to 2A113 (SU#3 feed to 2A1) as a result of phase to phase fault in the feed to the 2A1 bus
    - 2A2 de-energized and 2A4 powered from the #2 EDG. 2A1 and 2A3 slow transfer to SU#2.
    - 2H1 and 2H2 de-energized. RCPs and Circulating Water Pump secured
    - AFW Pump tripped on SU#2 load shed
    - Loss of Spent Fuel Pool (SFP) cooling due to 2P-40B trip
    - Re-entered SPTAs
    - Entered fire and explosion AOP
    - Entered Natural Circulation AOP
    - Entered Loss of Instrument Air AOP
- Letdown isolated, Normal Pressurizer Spray not available, Steam Dump Bypass Control System (SDBCS) unavailable, Running CCP tripped, RCS level rising – Pressurizer Heaters energized and RCS heated up
- Manually actuated EFAS when AFW pump tripped
- Re-started instrument air compressor (header pressure would only maintain 45 psi)
- Control Room phones unavailable
- Significant water hammer on east turbine deck due to low instrument air pressure and valves cycling
- Momentary loss of Safety Parameter Display System (SPDS) and Plant Computer Display in CR
- Cross tied non-vital buses 2B1 and 2B2 to allow start of the 2nd instrument air compressor header pressure raised to 90 psi
- Started 2P-40A SFP cooling pump
- Declared Notification of Unusual Event (NUE) (HU-4) based on minor explosion damaging plant equipment. Visible damage to back of 2A113 observed.

The operator response to the event was effective with actions taken to maintain the plants in a safe and stable condition despite the challenges associate with the lift assembly failure, medical response for injured personnel and the challenges associated with degraded power condition. All safety systems performed as designed aiding the operators in the event recovery.

[redacted]

Exhibit 4 - **Code Requirements**

Material Handling Program
Applicable Codes per EN-MA-119

EN-MA-119 Section applicable to specially designed lifting devices	EN-MA-119 Section Summary	Industry code applicability		Summary as applied to "specially designed lifting devices"
[redacted]	[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]	[redacted]

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Exhibit 4 - **Code Requirements**

[redacted]

EN-MA-119 Section applicable to specially designed lifting devices	EN-MA-119 Section Summary	Industry code applicability		Summary as applied to "specially designed lifting devices"
		[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]	[redacted]

[redacted]

Exhibit 4 - **Code Requirements**

Material Handling Program
Applicable Codes per EN-MA-119

EN-MA-119 Section applicable to specially designed lifting devices	EN-MA-119 Section Summary	Industry code applicability		Summary as applied to "specially designed lifting devices"
		[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]	[redacted]

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Exhibit 5 – Bigge Gantry Crane Tower System Failure Contingency Plan

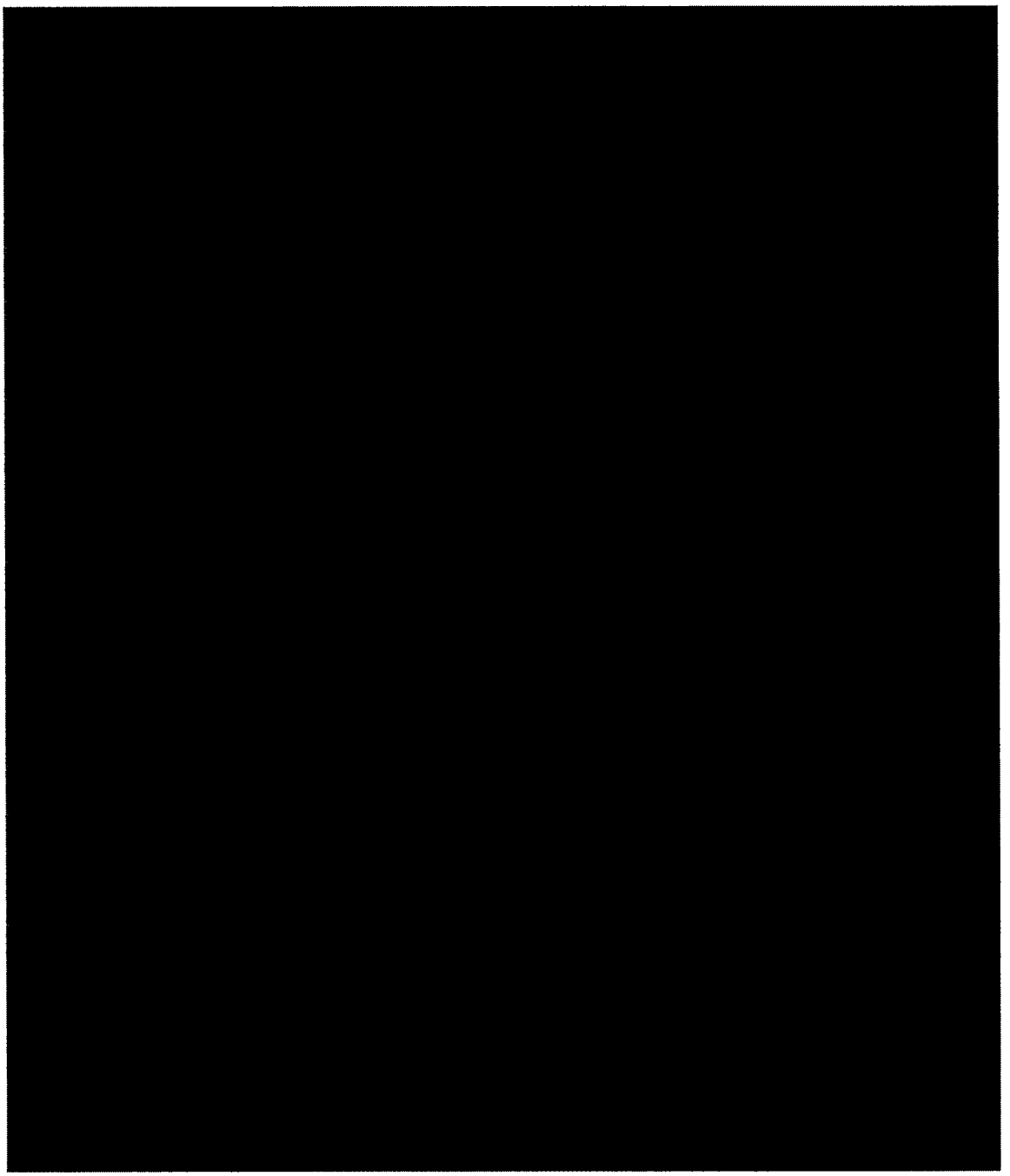

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Exhibit 5 – Bigge Gantry Crane Tower System Failure Contingency Plan

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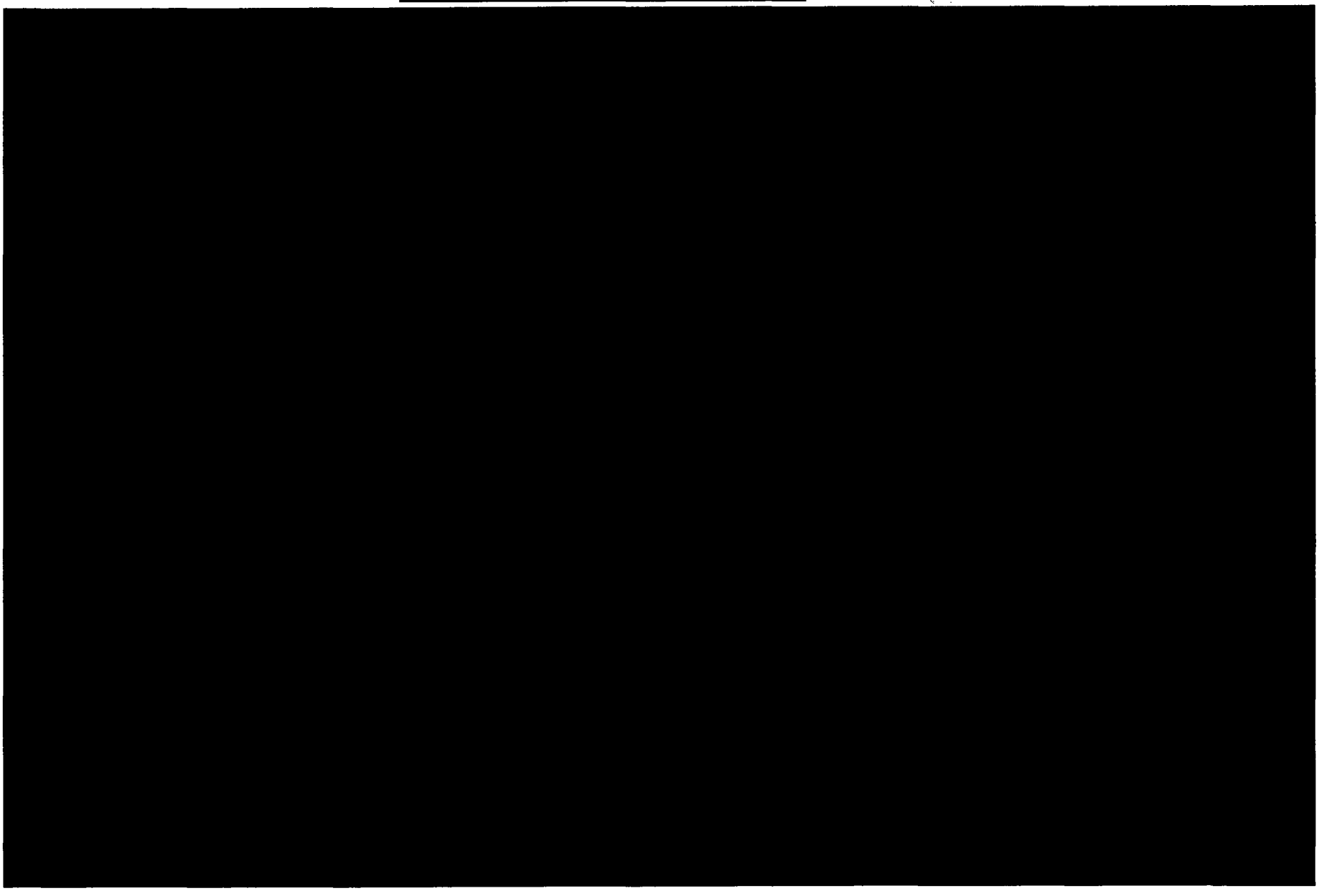
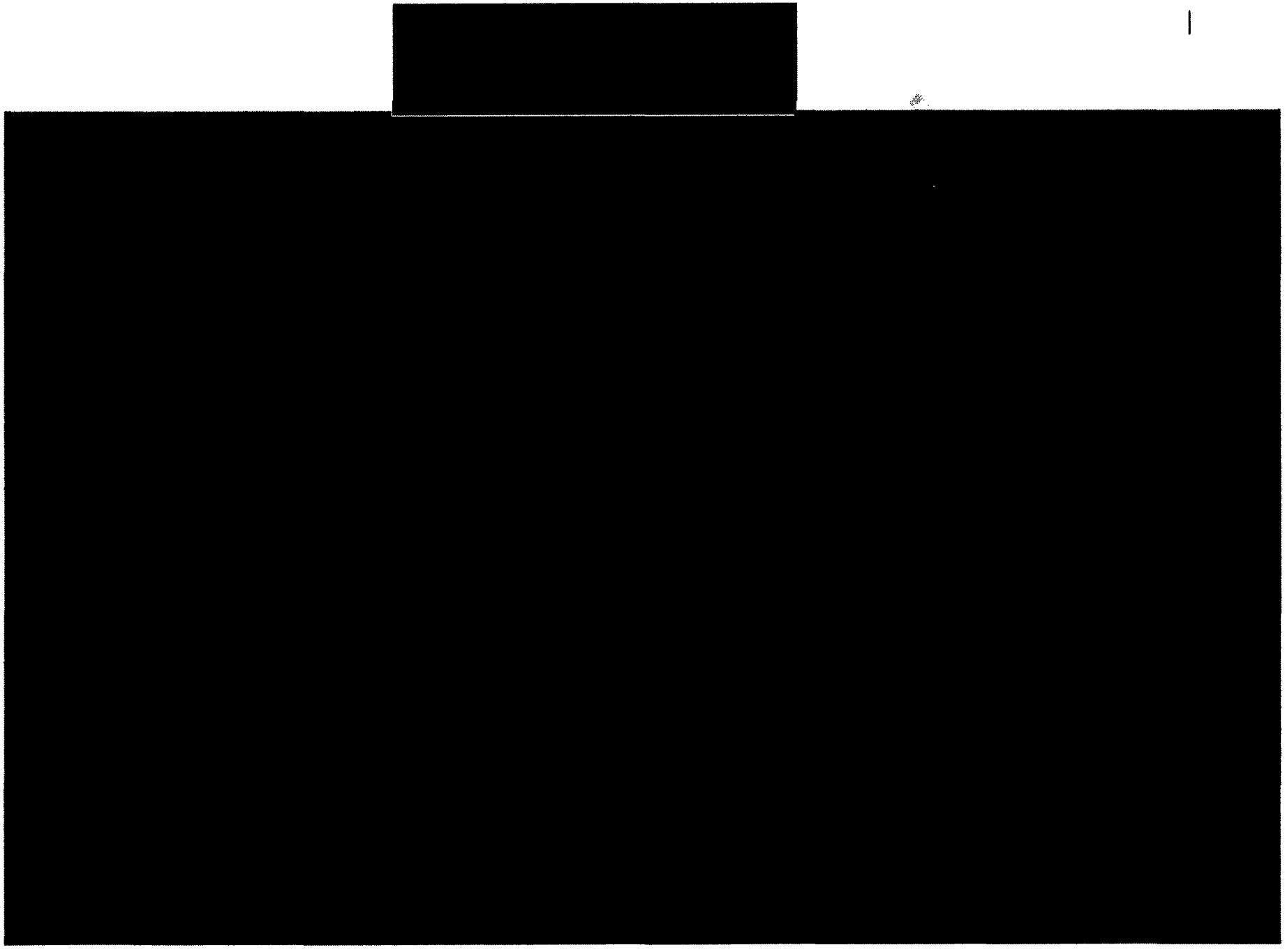
Attachment 1 – Fault Tree





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Attachment 2 –Events and Causal Factors Chart

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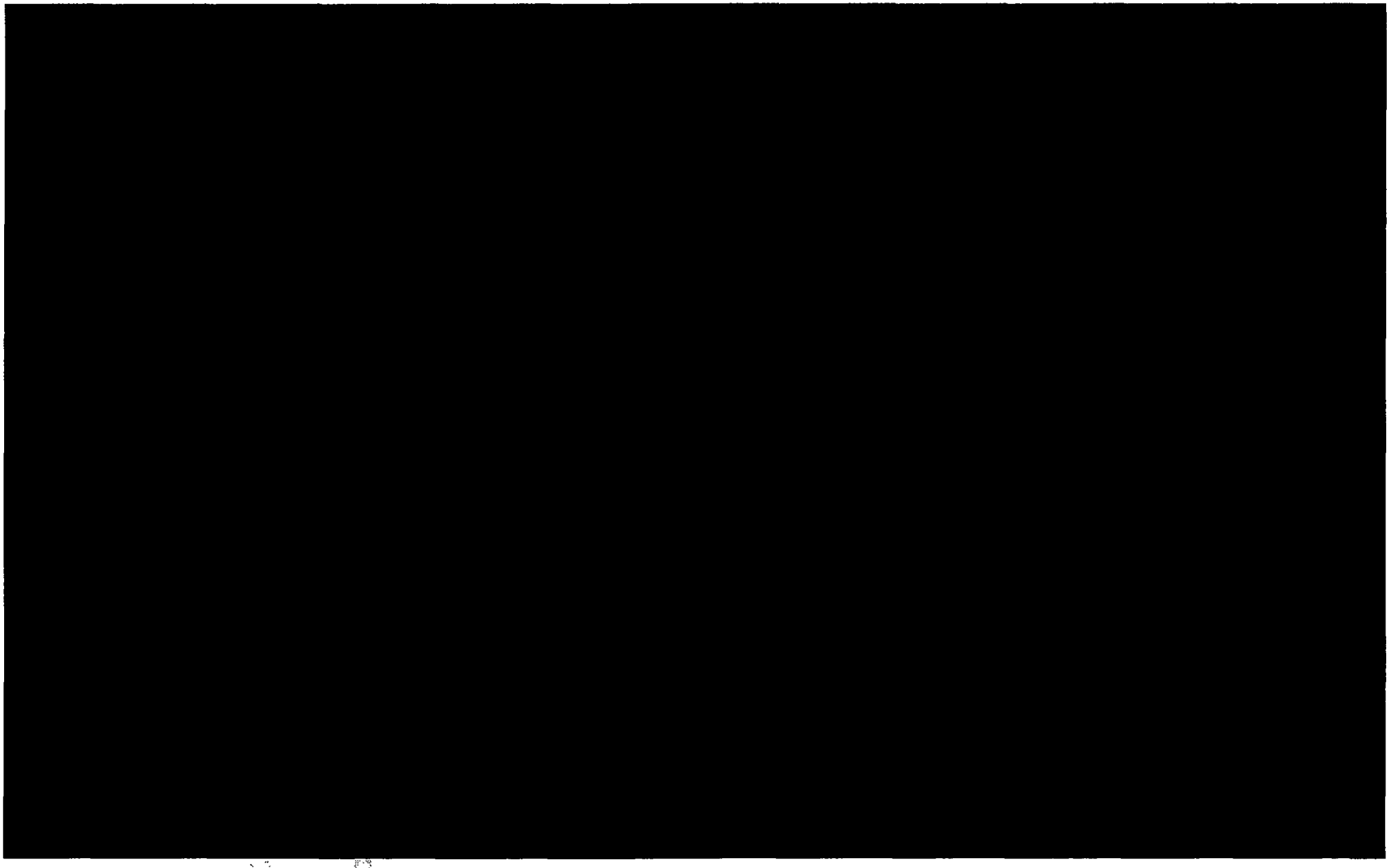
Attachment 2 –Events and Causal Factors Chart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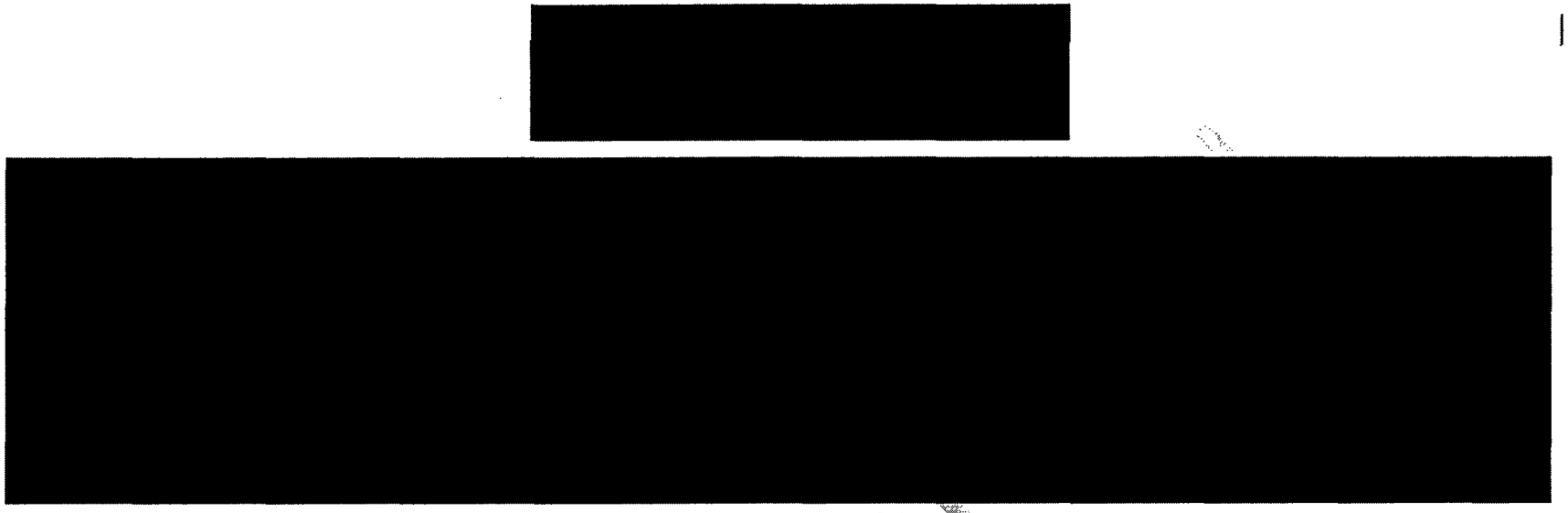

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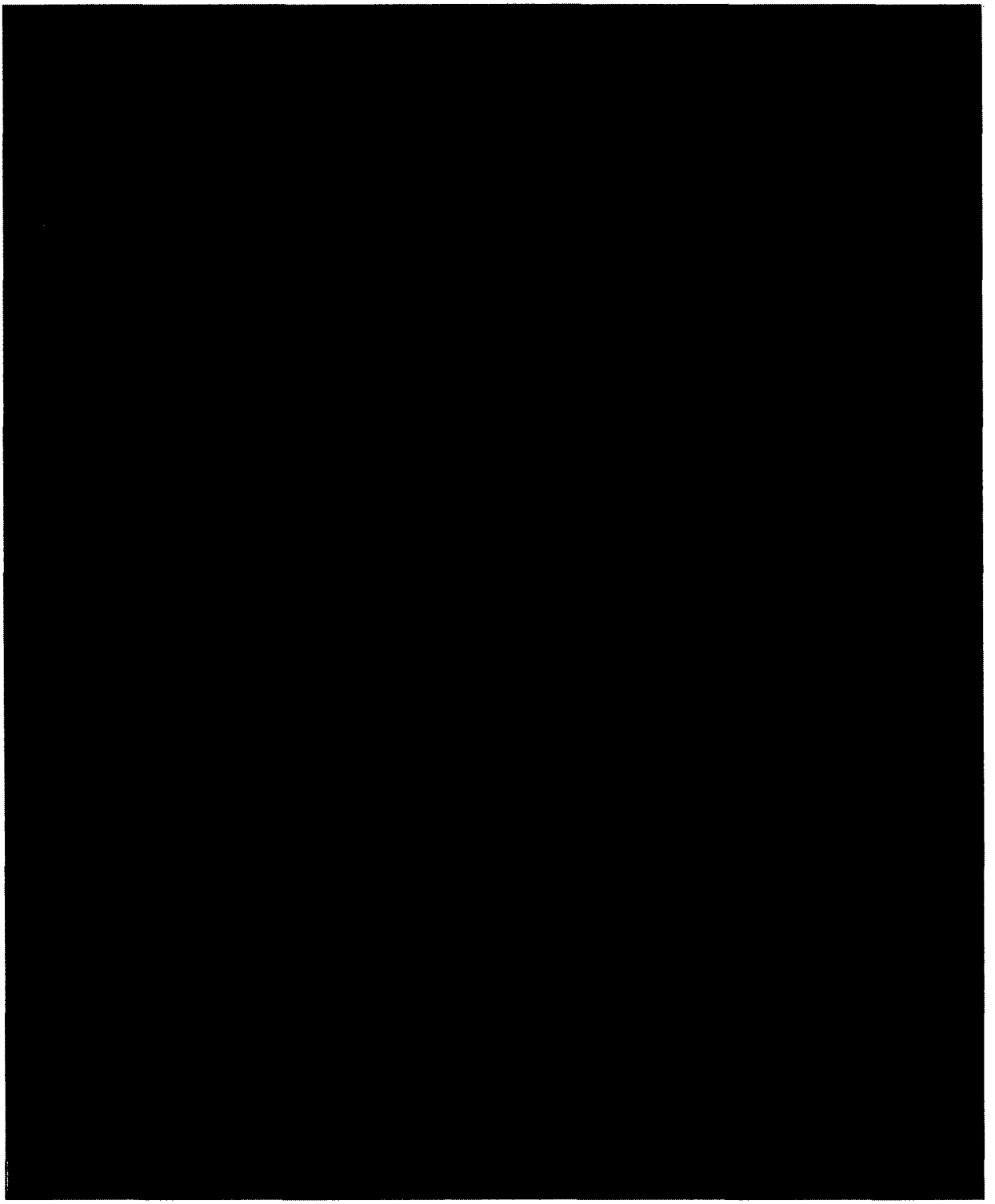
Attachment 3a – [redacted] Structural Evaluation Status Report



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Attachment 3a – [redacted] Structural Evaluation Status Report

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Attachment 3a – [redacted] Structural Evaluation Status Report

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Attachment 3a – [redacted] Structural Evaluation Status Report

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Attachment 3a – [redacted] Structural Evaluation Status Report

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Attachment 3a – [redacted] Structural Evaluation Status Report

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Attachment 3a – [redacted] Structural Evaluation Status Report

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Attachment 3a – [redacted] Structural Evaluation Status Report

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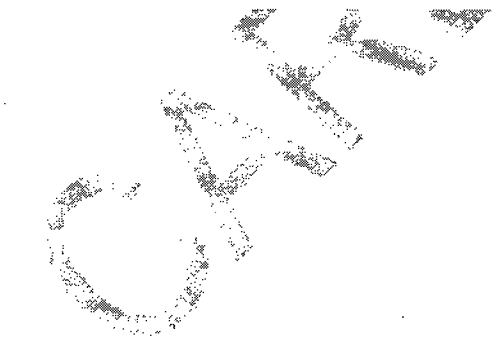

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Attachment 3b – Failure Modes Analysis

ATTACHMENT 9.1 **FAILURE MODE ANALYSIS WORKSHEET**

Problem Statement: On March 31, 2013, the temporary lift assembly collapsed while moving the generator stator to the train bay.

[redacted]

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Attachment 3b – Failure Modes Analysis

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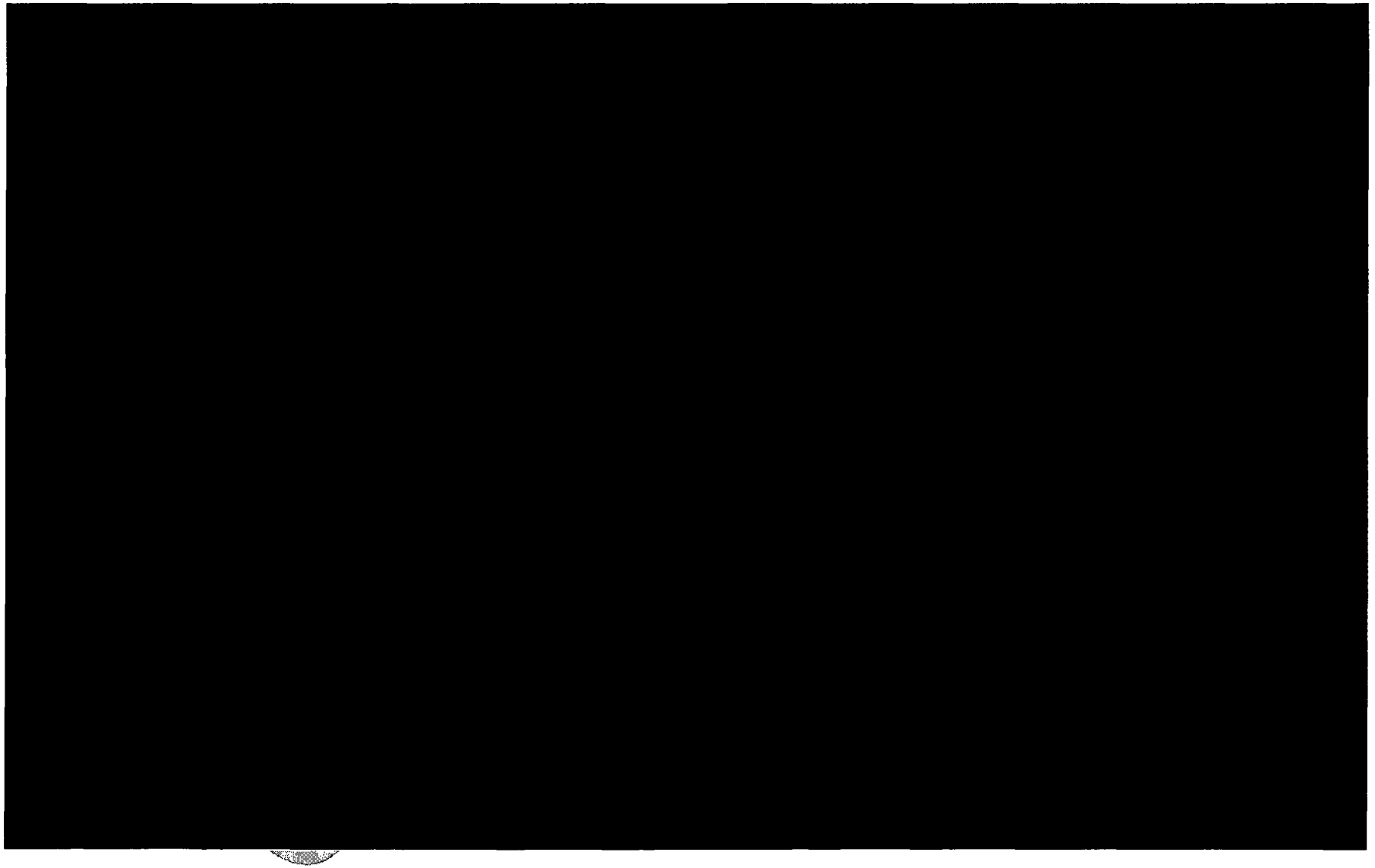
Attachment 3b – Failure Modes Analysis



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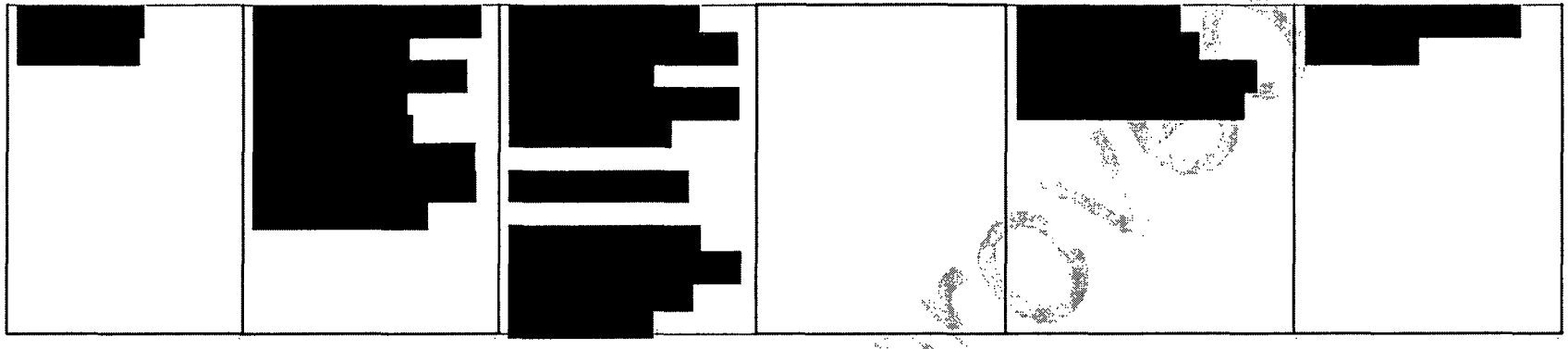
Attachment 3b – Failure Modes Analysis



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Attachment 3b – Failure Modes Analysis

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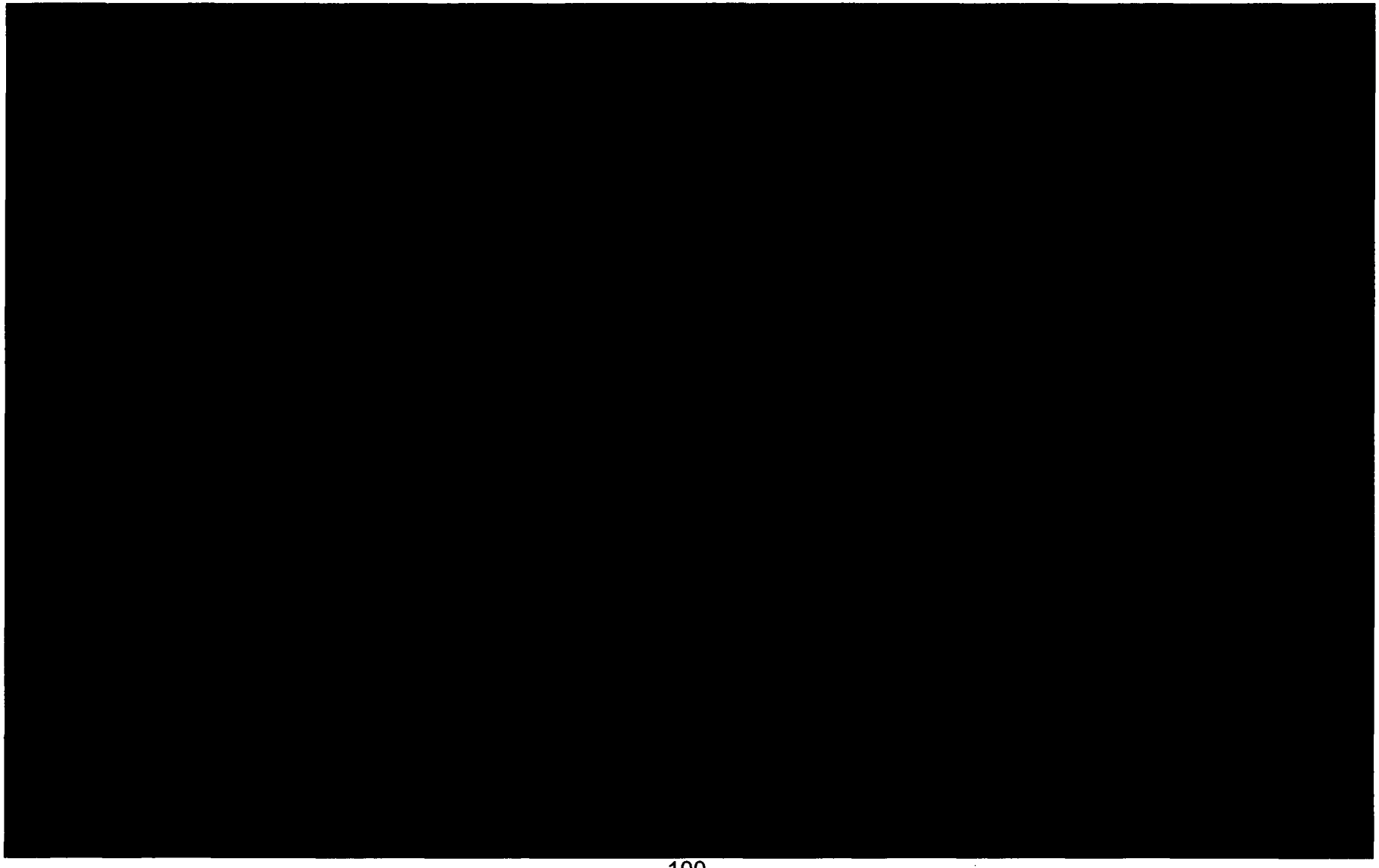
Attachment 3b – Failure Modes Analysis



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Attachment 3b – Failure Modes Analysis

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Attachment 3b – Failure Modes Analysis

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Attachment 3b – Failure Modes Analysis

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Attachment 3b – Failure Modes Analysis

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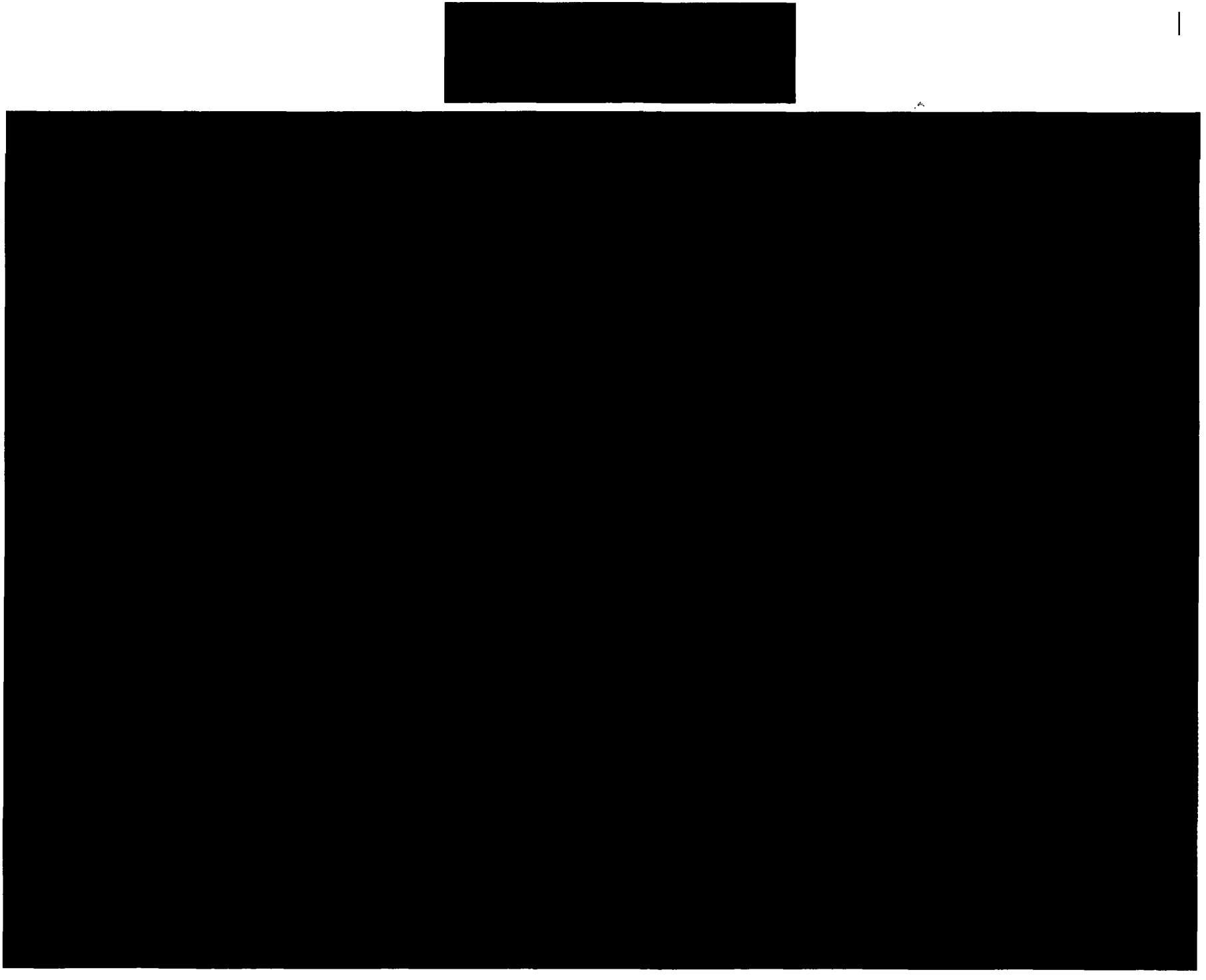

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Attachment 4 – Comparative Timeline

Comparative Time Line


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Attachment 4 – Comparative Timeline

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Attachment 4 – Comparative Timeline


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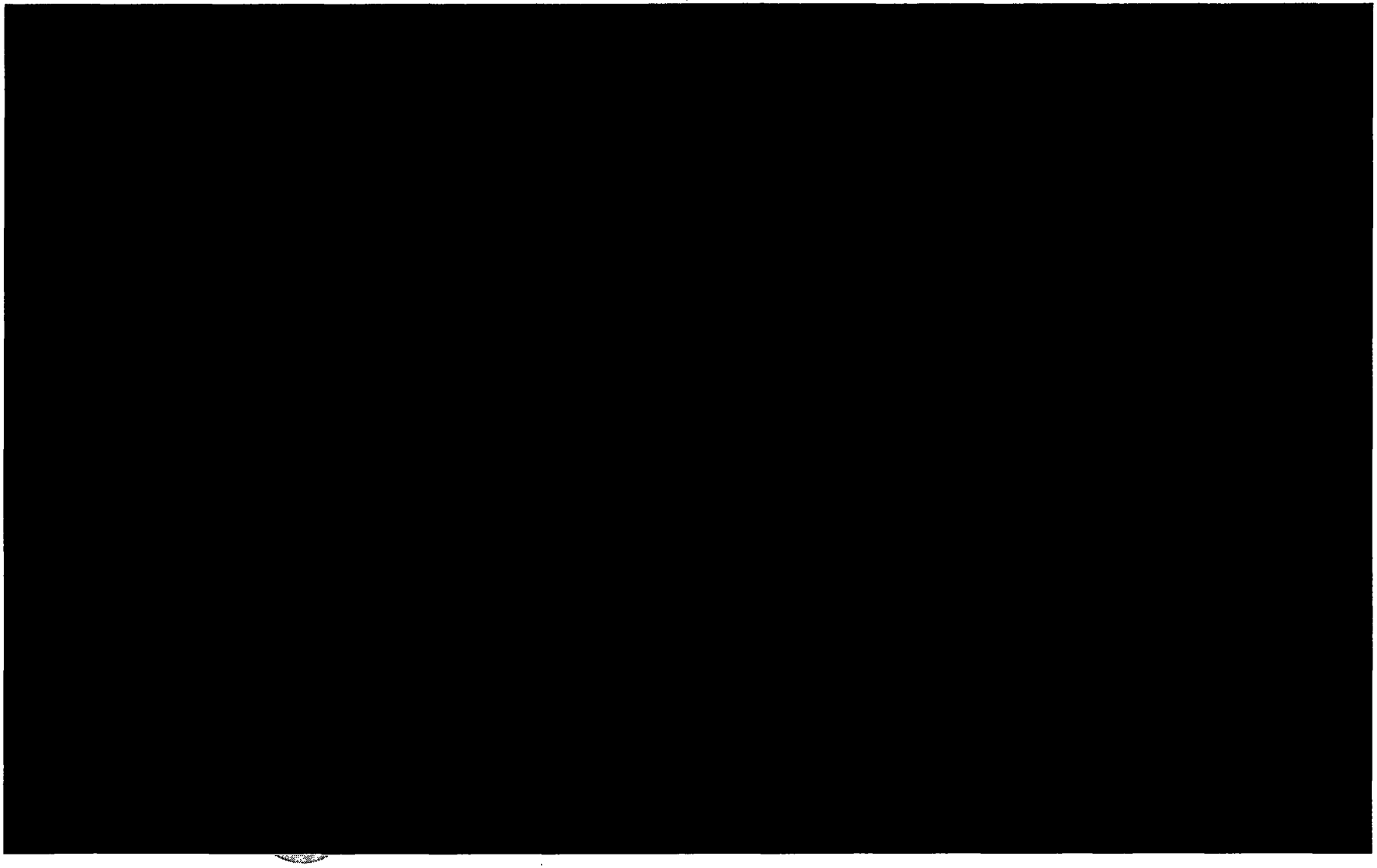
Attachment 4 – Comparative Timeline



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Attachment 4 – Comparative Timeline


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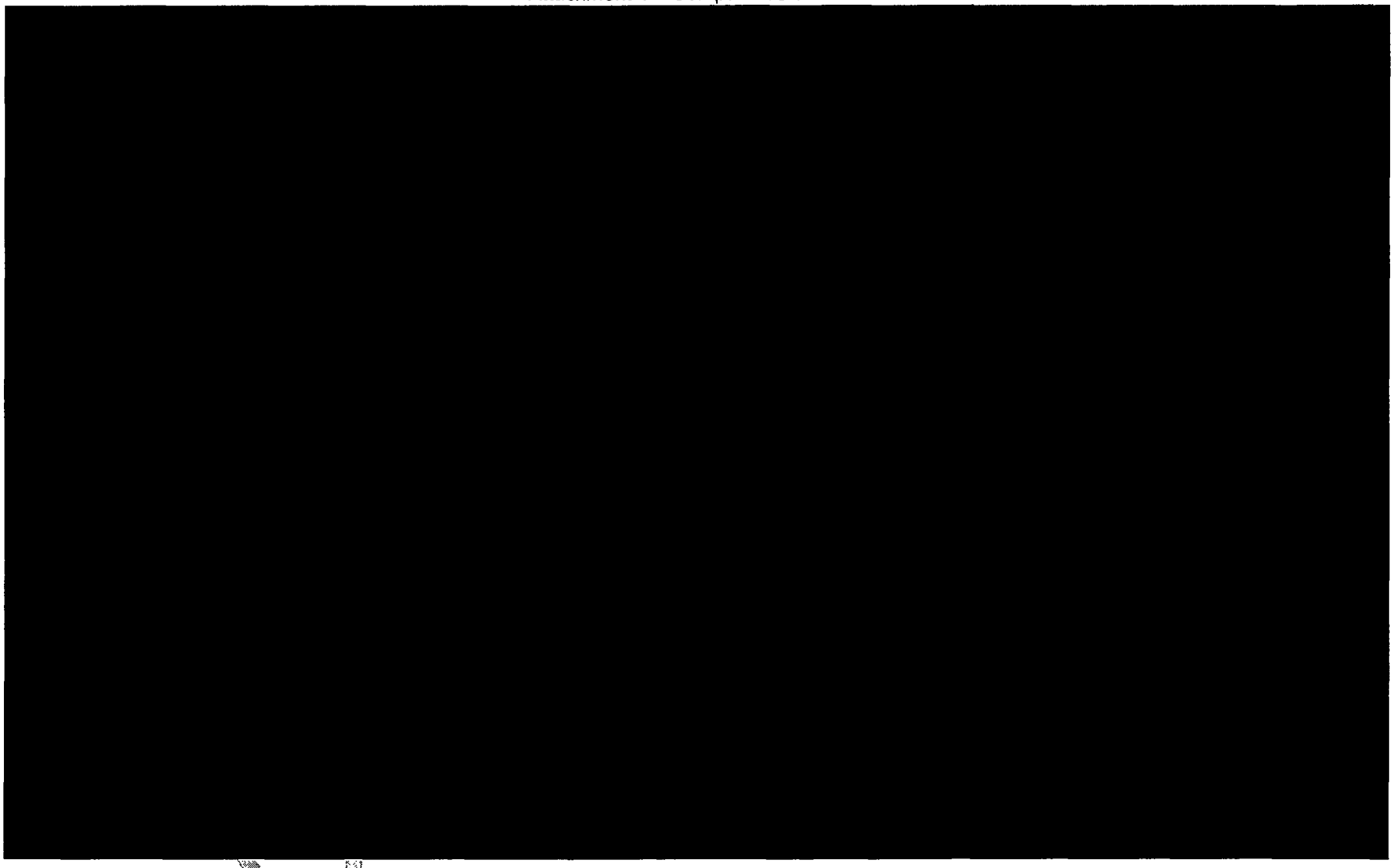
Attachment 4 – Comparative Timeline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Attachment 4 – Comparative Timeline


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Attachment 4 – Comparative Timeline

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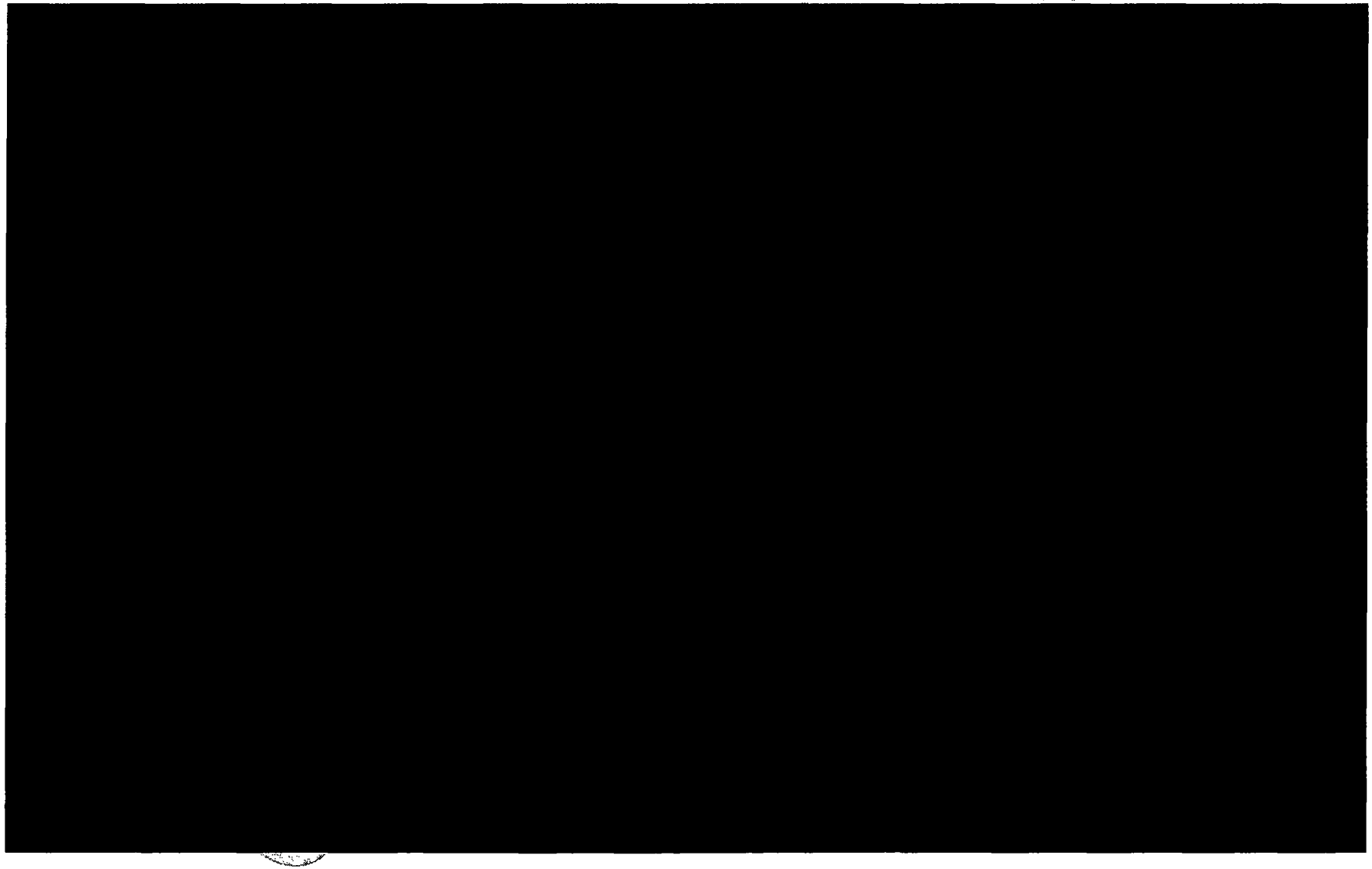
Attachment 4 – Comparative Timeline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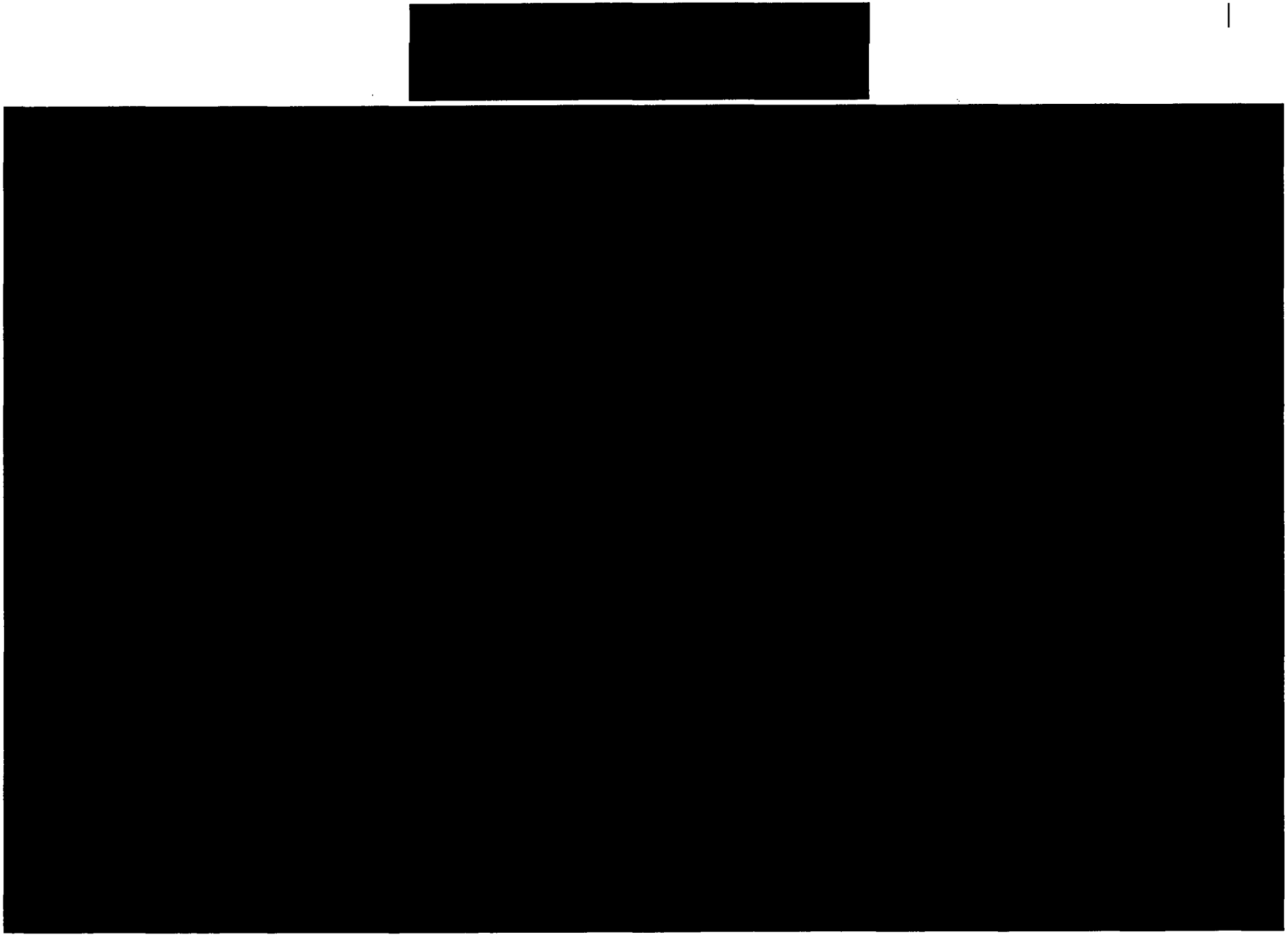

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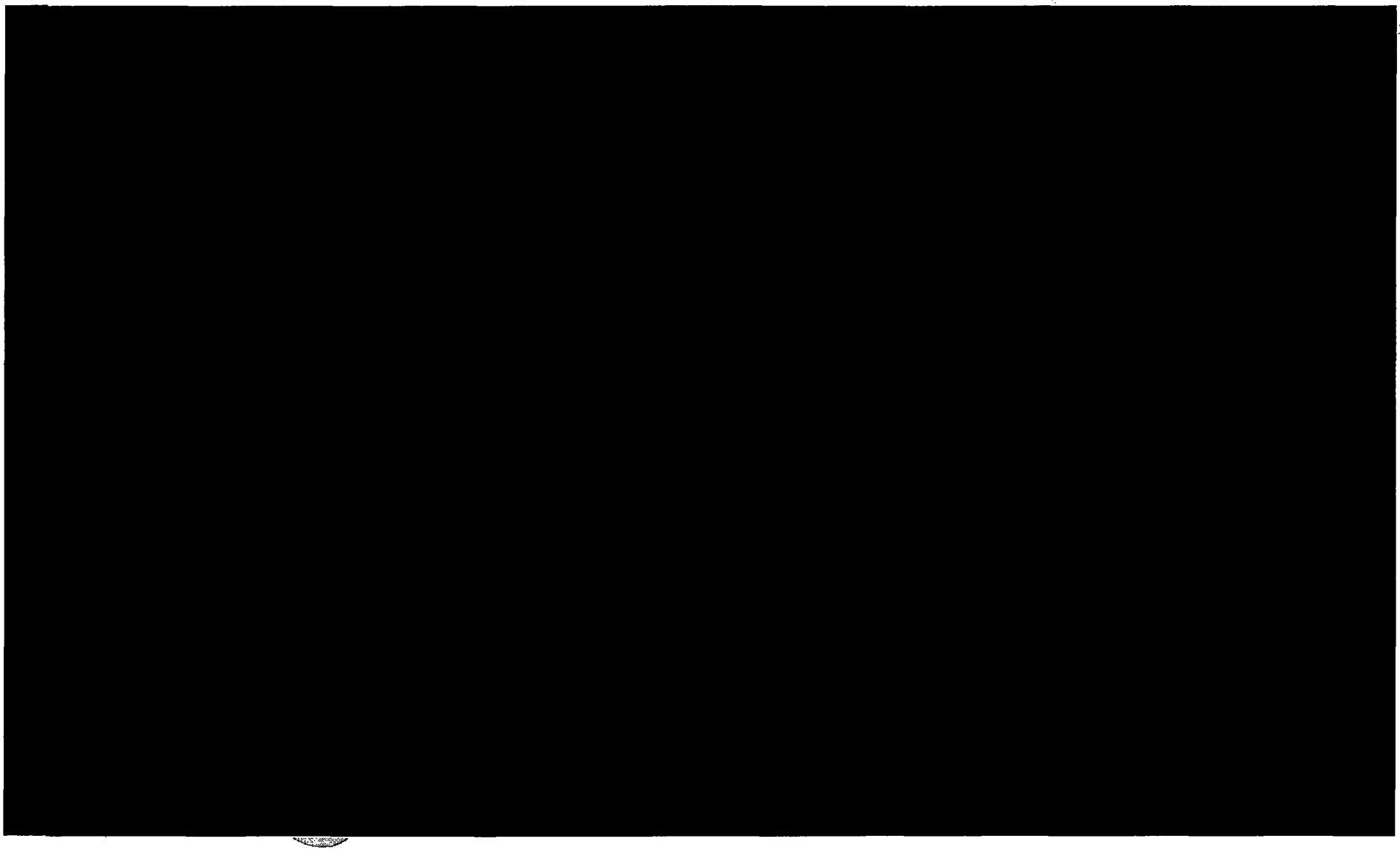
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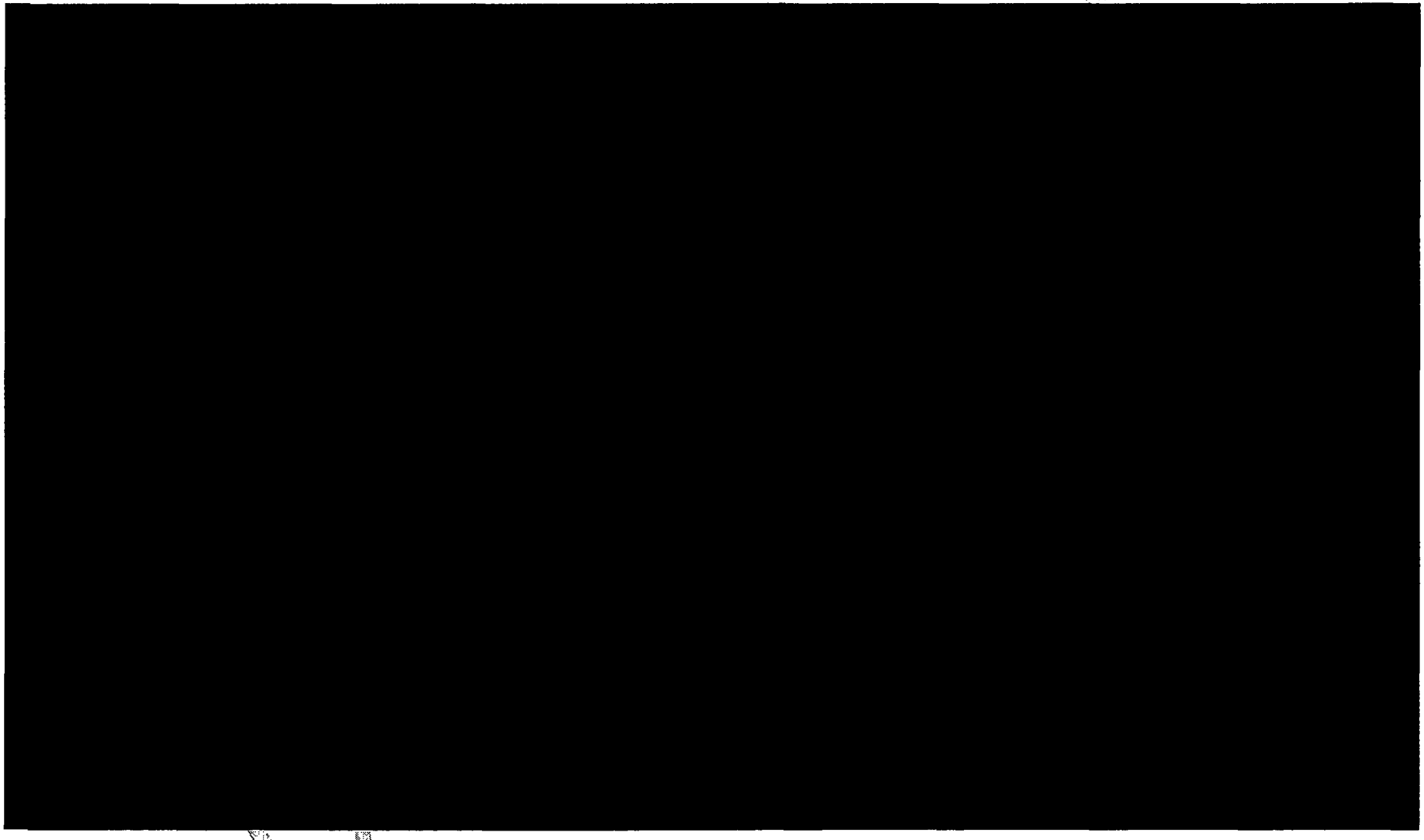
Attachment 4 – Comparative Timeline



General Guidance

It is not the intent of this activity to perform a "global" (i.e., site- or system-wide) search for O&P issues (LOWs). The scope of this activity should be limited to the event being investigated. If this evaluation is being performed for an Apparent Cause Evaluation, then substitute the term "root" with "apparent" and "RCE" with "ACE".

The questions below are intended to guide an evaluation for "local" O&P issues (LOWs) – that is, those O&P issues (LOWs) *which influenced the outcome of the event under investigation*. They represent the failure modes of the involved Organizations and implementing Programs (i.e., work processes).

The identified O&P factors shall be either causes or new adverse conditions requiring a condition report.

- The organization is not usually aware of their potential for influencing an event.
- They are typically EXTERNAL to the observed behaviors.

Since root cause investigation is a discovery process (a strongly knowledge-based activity, i.e., "you don't know what you don't know), this step serves as a valuable "tool" for the Evaluator (or team), to be used during the development of the causes.

This evaluation should typically be performed as part of the "Analyze" portion of the process.

For this process to be most effective, it is important that all the organizations and programs (work processes) which interacted during the event are known.

The Organizational and Programmatic qualified individual should provide oversight and coaching as necessary during the process.

Process

The root cause evaluator (or team) performs each of the following steps:

1. **Screen** each of the five failure mode areas to determine if the applicable causal factors may be related to the event. Based on the results of the determination, use the O&P questions below to identify whether any causal factor indicates the presence of organizational or programmatic weaknesses.
2. **Initiate** documentation for any identified O&P issues (LOWs) that do not appear to have a "cause & effect" relationship to the investigated event – initiate a new CR.
3. **Document** the results of this evaluation (including a brief summary of supporting facts) for each of the failure modes that apply in the Organizational and Programmatic Weakness Evaluation section.

a. For any O&P causal factors identified as contributing to the event discuss how this factor is related to the appropriate cause.

b. Discuss any identified O&P issues (LOWs) that do not appear to have a "cause & effect" relationship to the investigated event. Document the new CR initiated.

c. Ensure failure modes that apply are evaluated and documented in this section.

[redacted]

ATTACHMENT 9.5 **EVALUATION FOR ORGANIZATION & PROGRAMMATIC ISSUES**

Sheet 2 of 13

Beginning of Form

Attach this Worksheet to the Disposition CA in PCRS if not incorporated in the RCE. The questions are provided to promote consideration of like symptoms, not to define a specific failure mode. O&P causal factors are symptoms of the more basic causes of the event and are typically an action or condition that shaped the outcome of the situation.

For each causal factor block checked YES:

1. Ensure it is appropriately represented in the WHY Staircase as a cause or contributor.
2. In the BARRIER ANALYSIS, tie the O&P causal factors as appropriate to Barriers that failed, were weak, missing, or ineffective.
3. Summarize in the O&P section of the report how the identified Organizational & Programmatic weaknesses caused or contributed to the event and identify the Barrier which should have prevented it.

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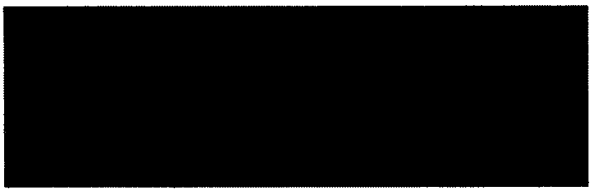
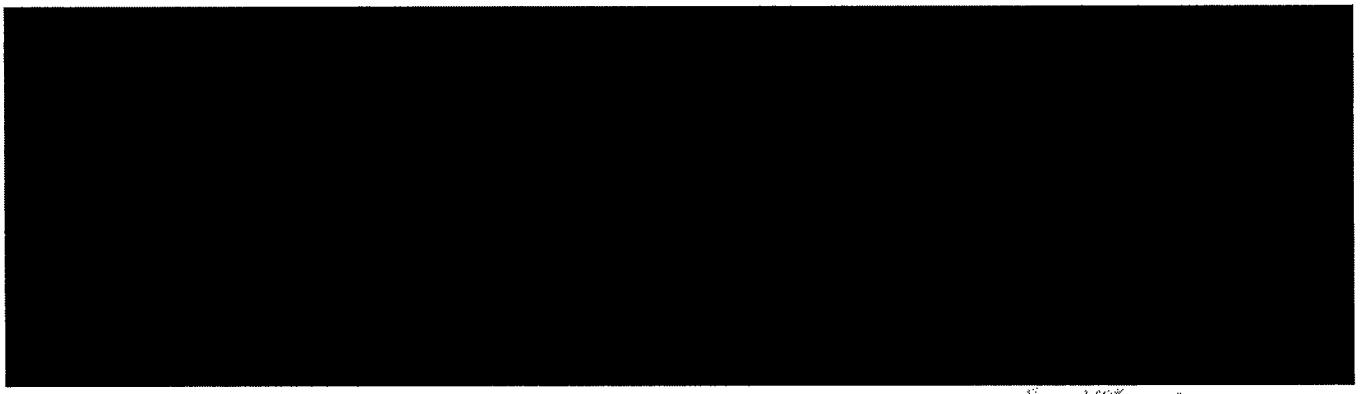


Attachment 5 – Organizational and Programmatic Analysis (O&P)



ATTACHMENT 9.5 EVALUATION FOR ORGANIZATION & PROGRAMMATIC ISSUES
Sheet 3 of 13

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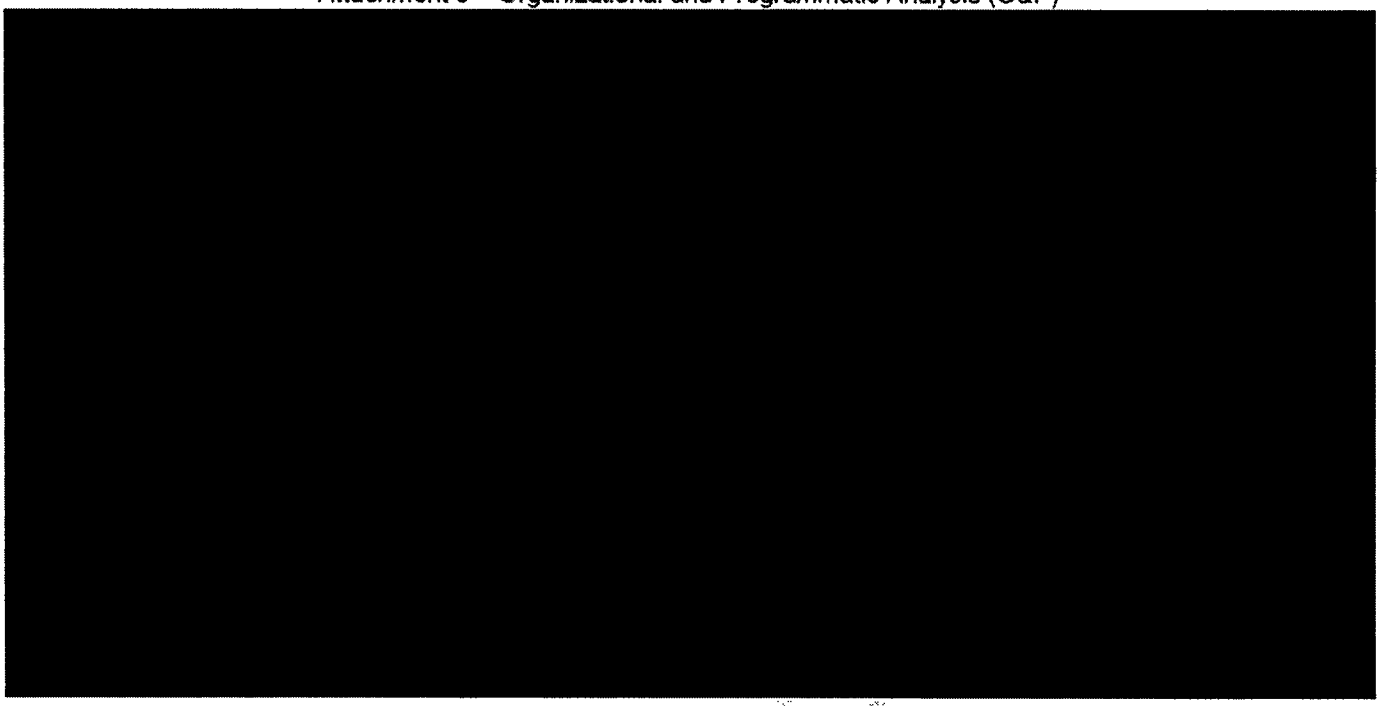
Attachment 5 – Organizational and Programmatic Analysis (O&P)



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Attachment 5 – Organizational and Programmatic Analysis (O&P)

ATTACHMENT 9.5 **EVALUATION FOR ORGANIZATION & PROGRAMMATIC ISSUES**

Sheet 5 of 13

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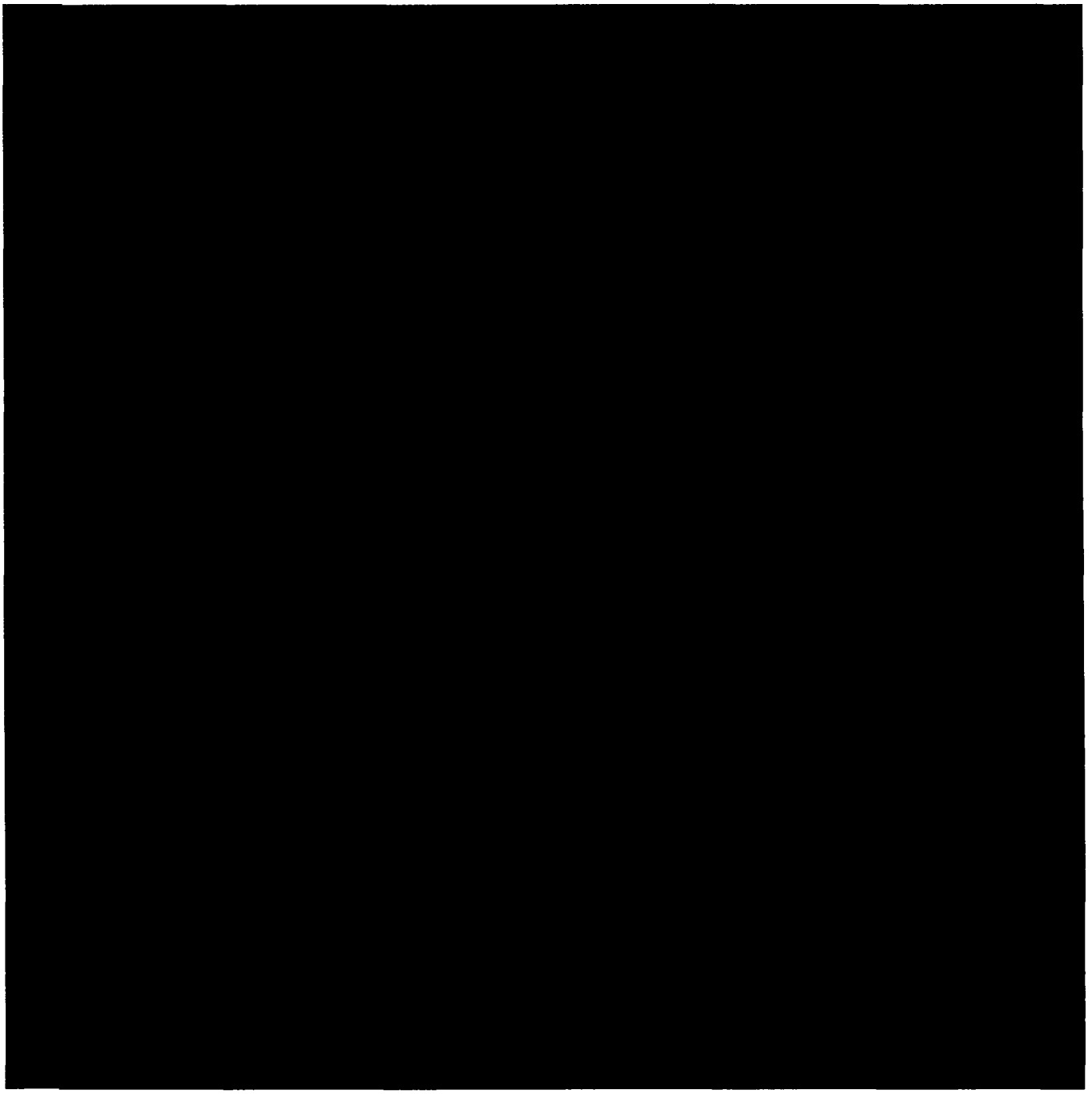
Attachment 5 – Organizational and Programmatic Analysis (O&P)



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Attachment 5 – Organizational and Programmatic Analysis (O&P)

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ATTACHMENT 9.5 **EVALUATION FOR ORGANIZATION & PROGRAMMATIC ISSUES**

Sheet 8 of 13

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ATTACHMENT 9.5 **EVALUATION FOR ORGANIZATION & PROGRAMMATIC ISSUES**

Sheet 10 of 13

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ATTACHMENT 9.6 **SAFETY CULTURE EVALUATION**

Sheet 4 of 10

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Attachment 6 – Safety Culture Analysis

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ATTACHMENT 9.6 **SAFETY CULTURE EVALUATION**

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ATTACHMENT 9.6 **SAFETY CULTURE EVALUATION**

Sheet 9 of 10

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Attachment 6 – Safety Culture Analysis

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Attachment 6 – Safety Culture Analysis

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Attachment 7 – CRs Closed to CR-ANO-C-2013-00888

CRs Closed to this RCE.

- [redacted]
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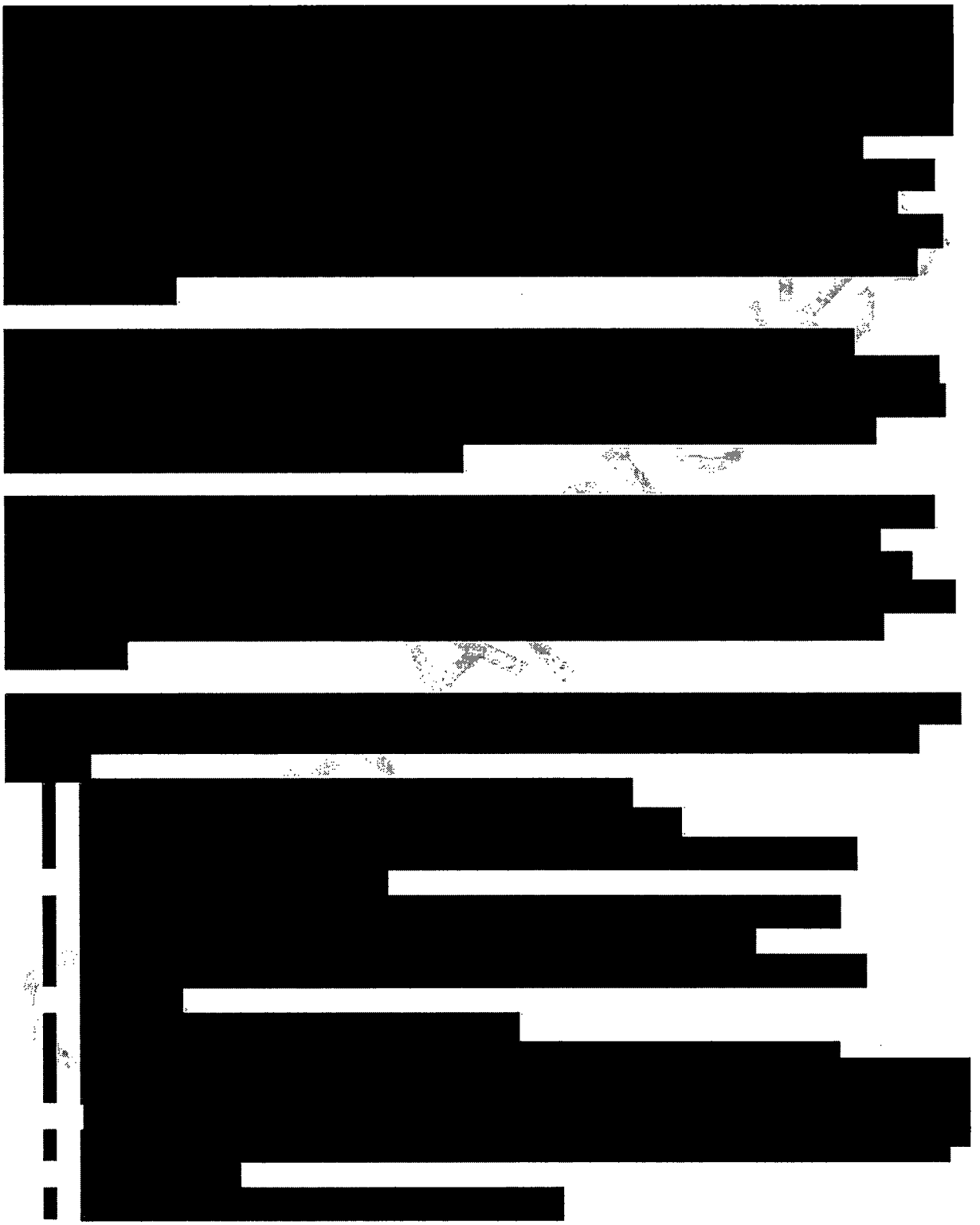
Attachment 8 - Acknowledgement of limitations



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Attachment 8 - Acknowledgement of limitations

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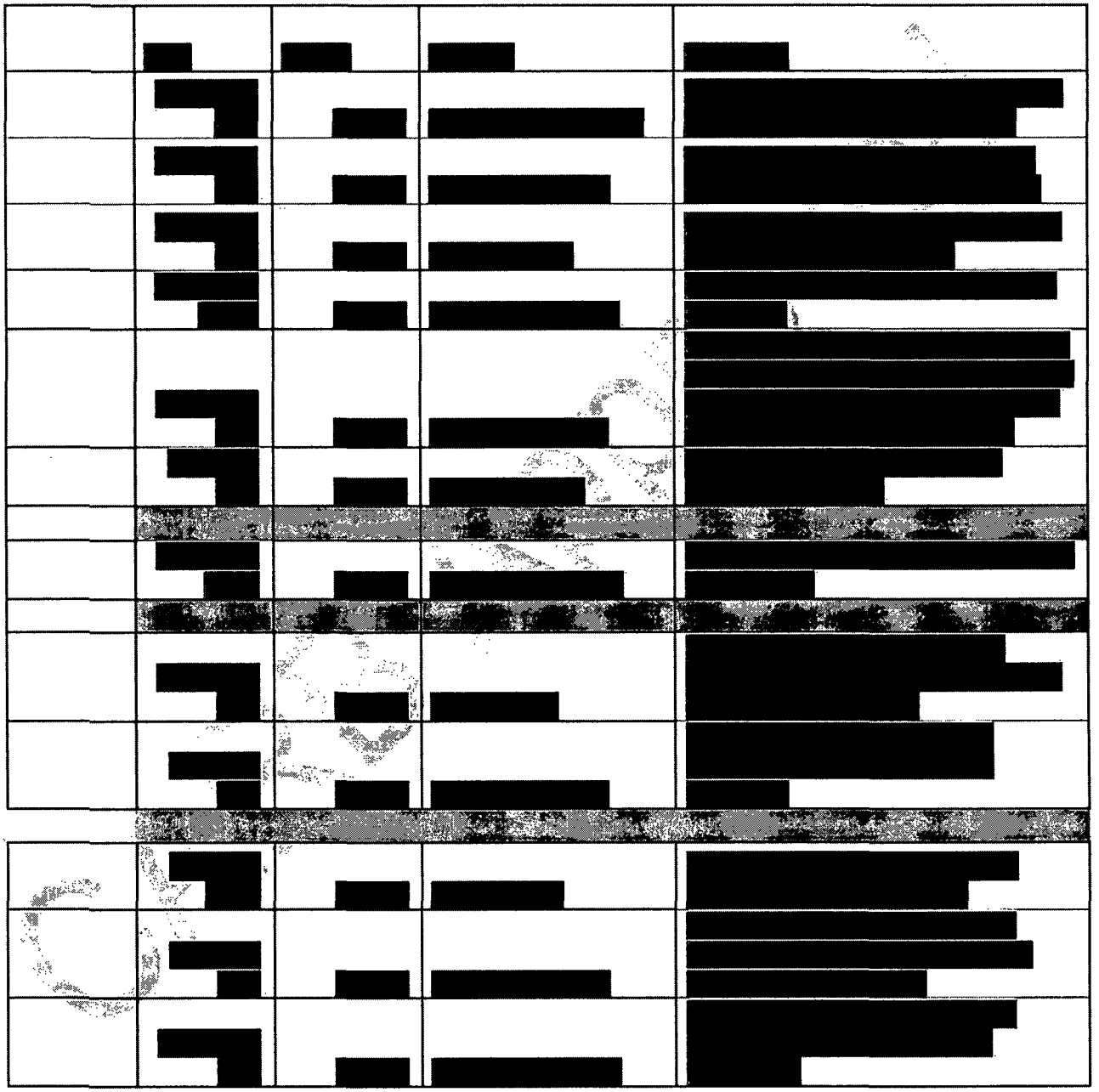
Attachment 9 – Operating Experience Review

OE Searches of ICES, EPRI and general internet searches were conducted to identify OE [redacted]



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Attachment 9 – Operating Experience Review

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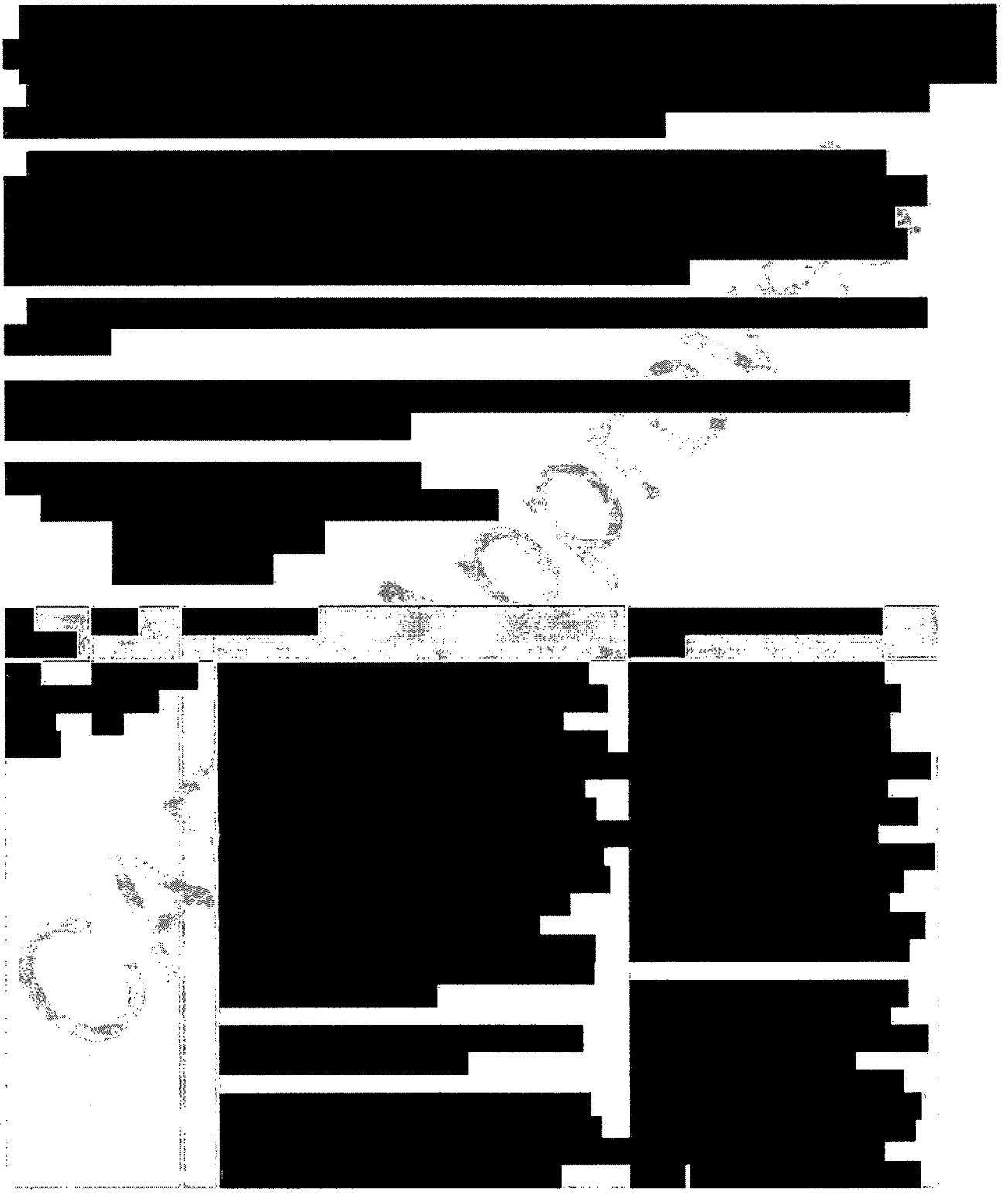

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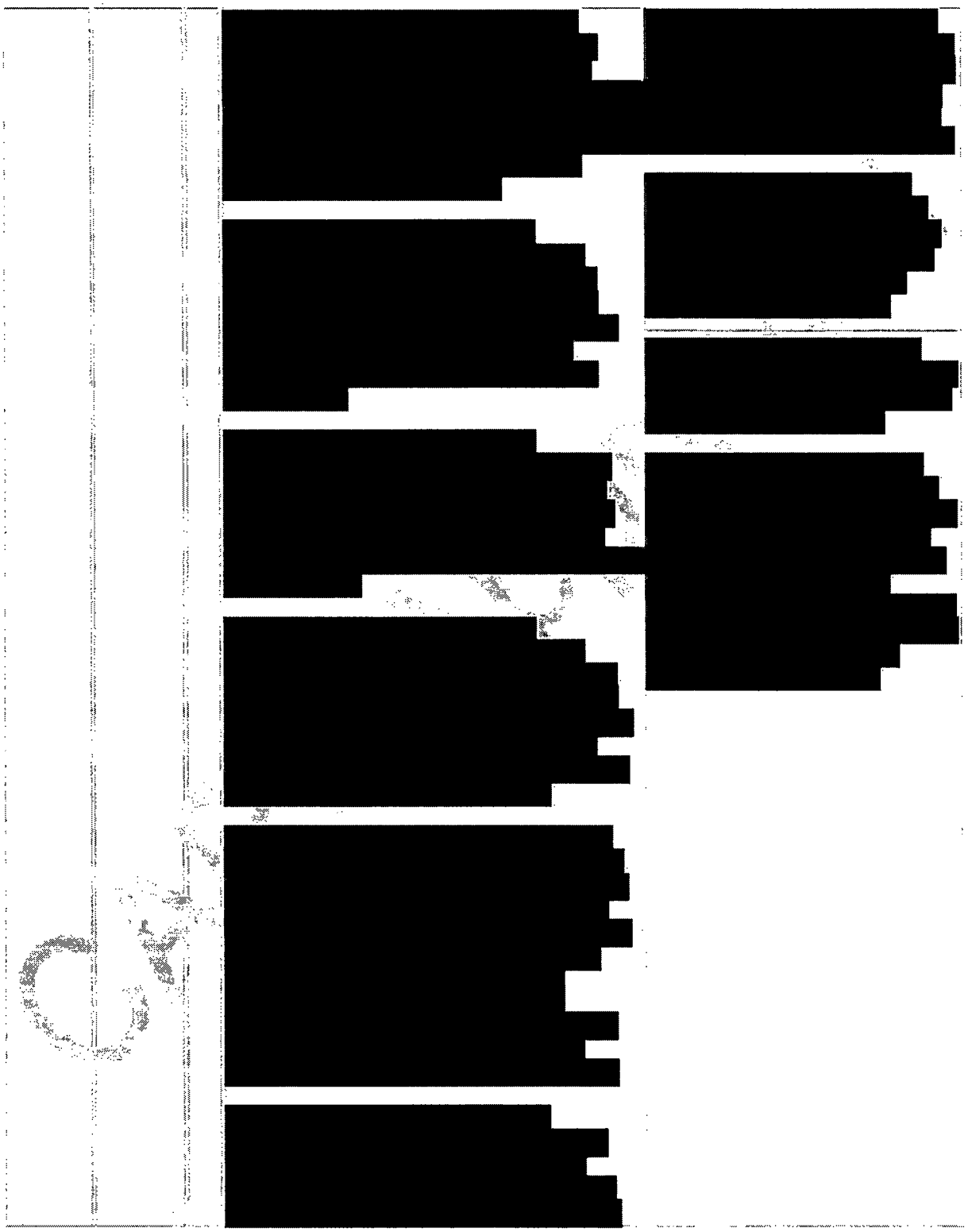
Attachment 9 – Operating Experience Review



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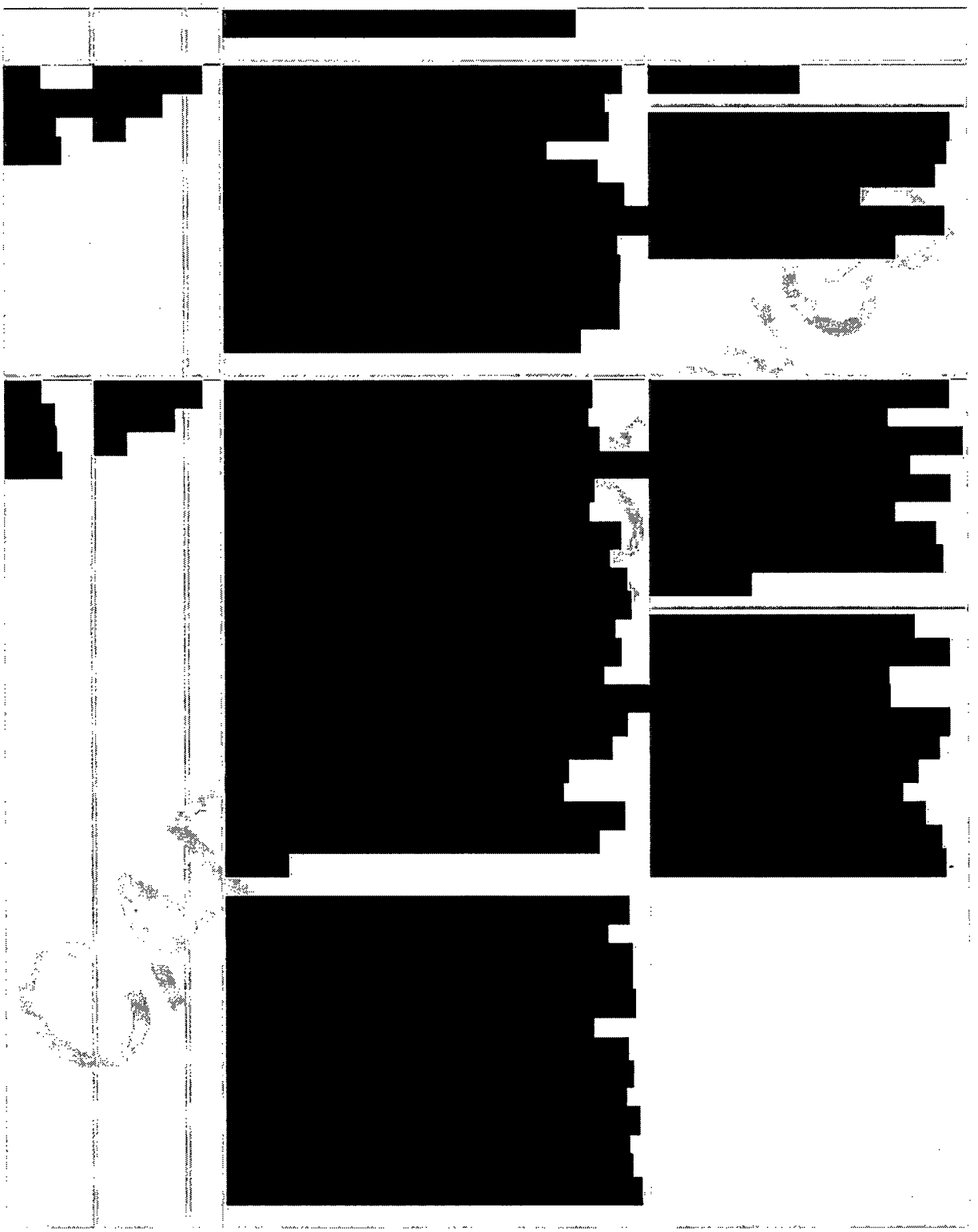

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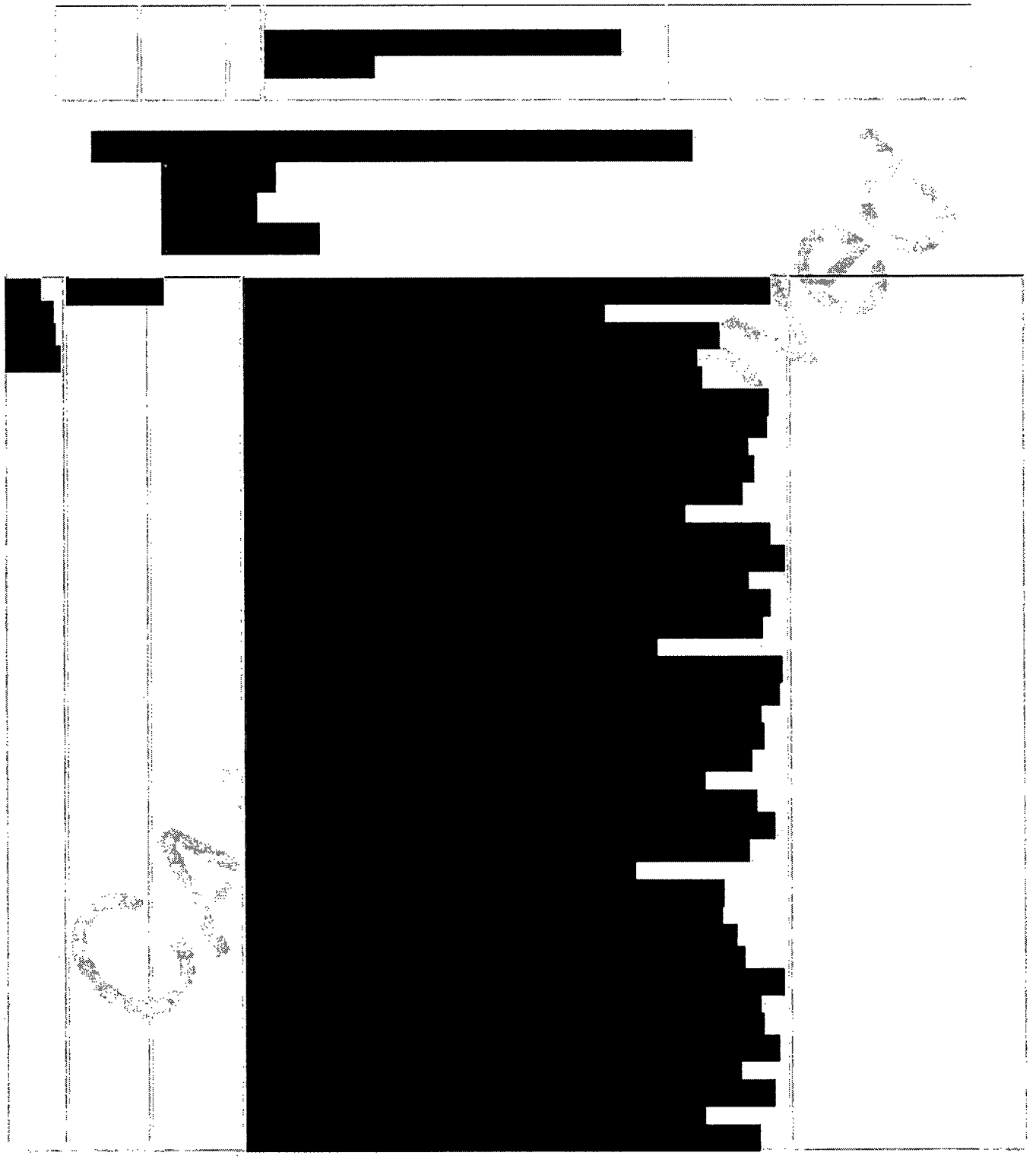

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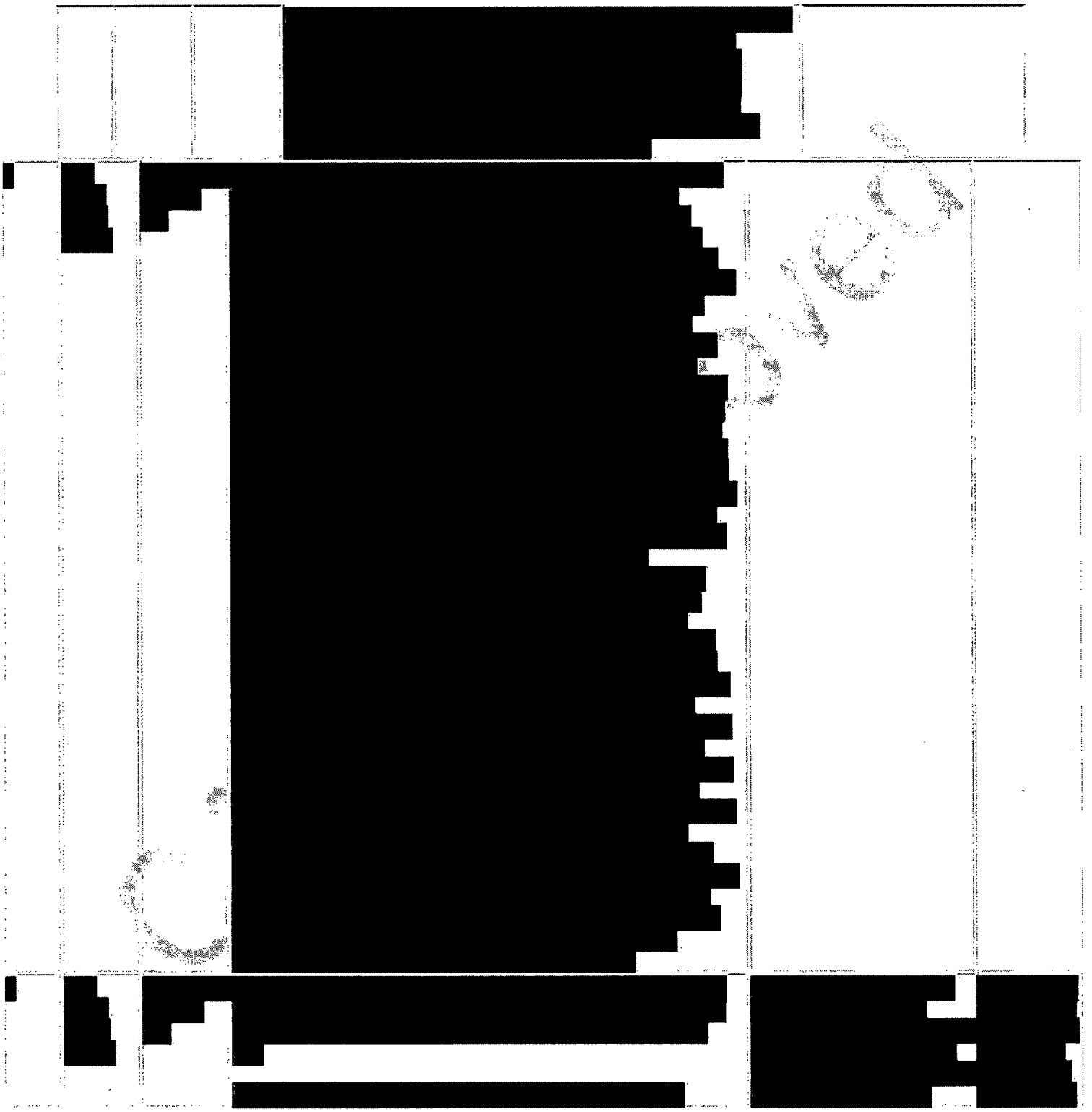

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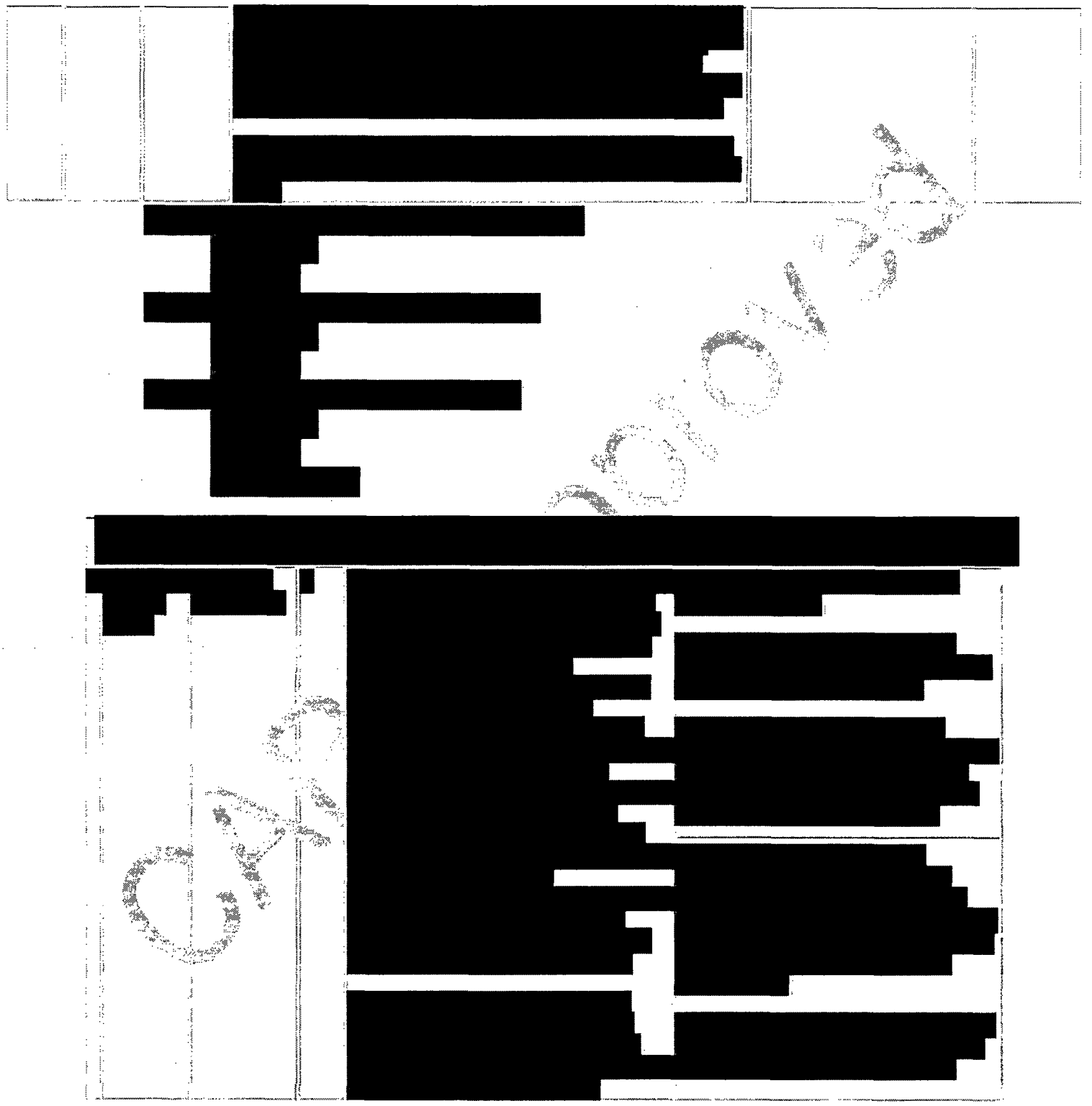

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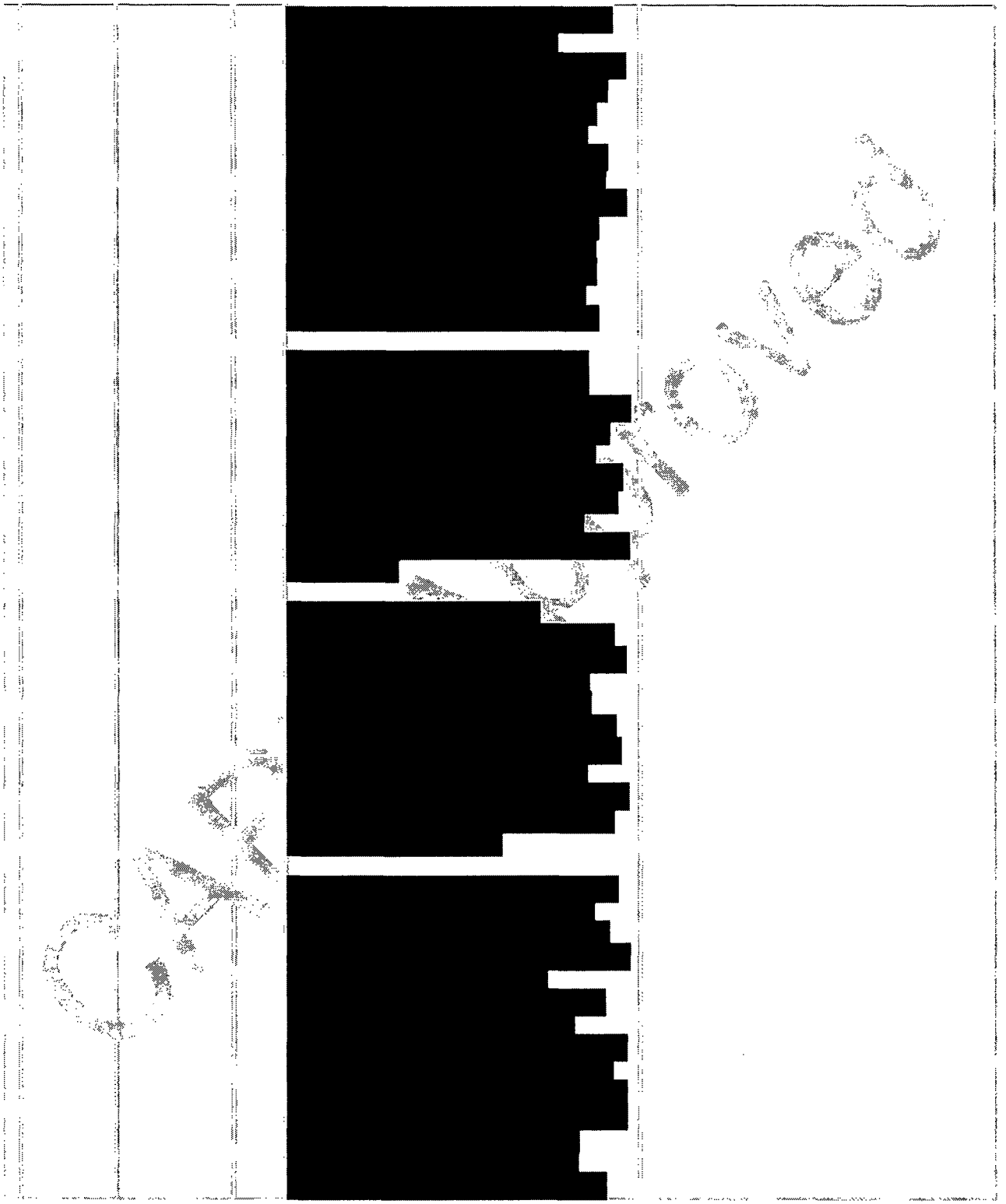

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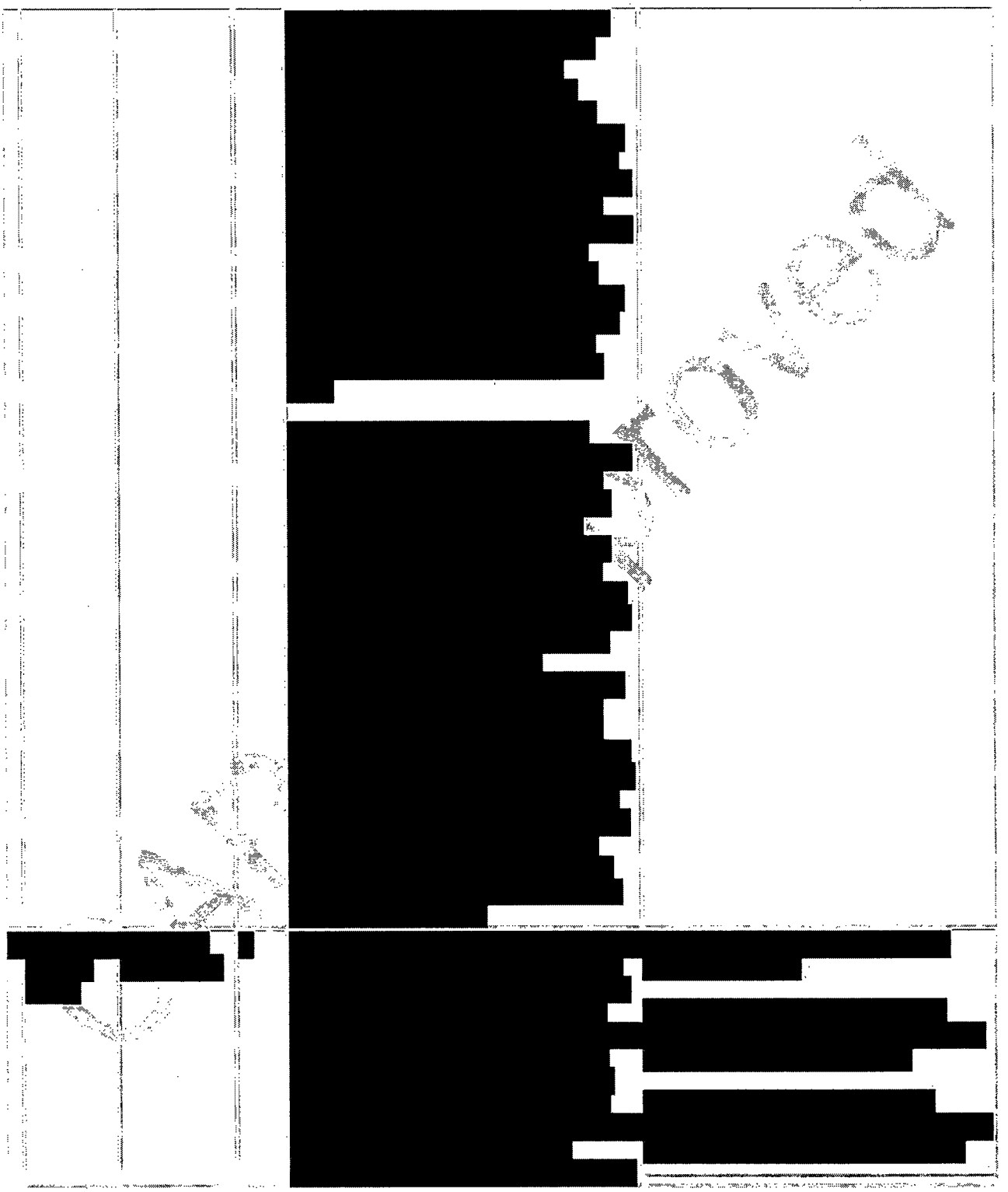

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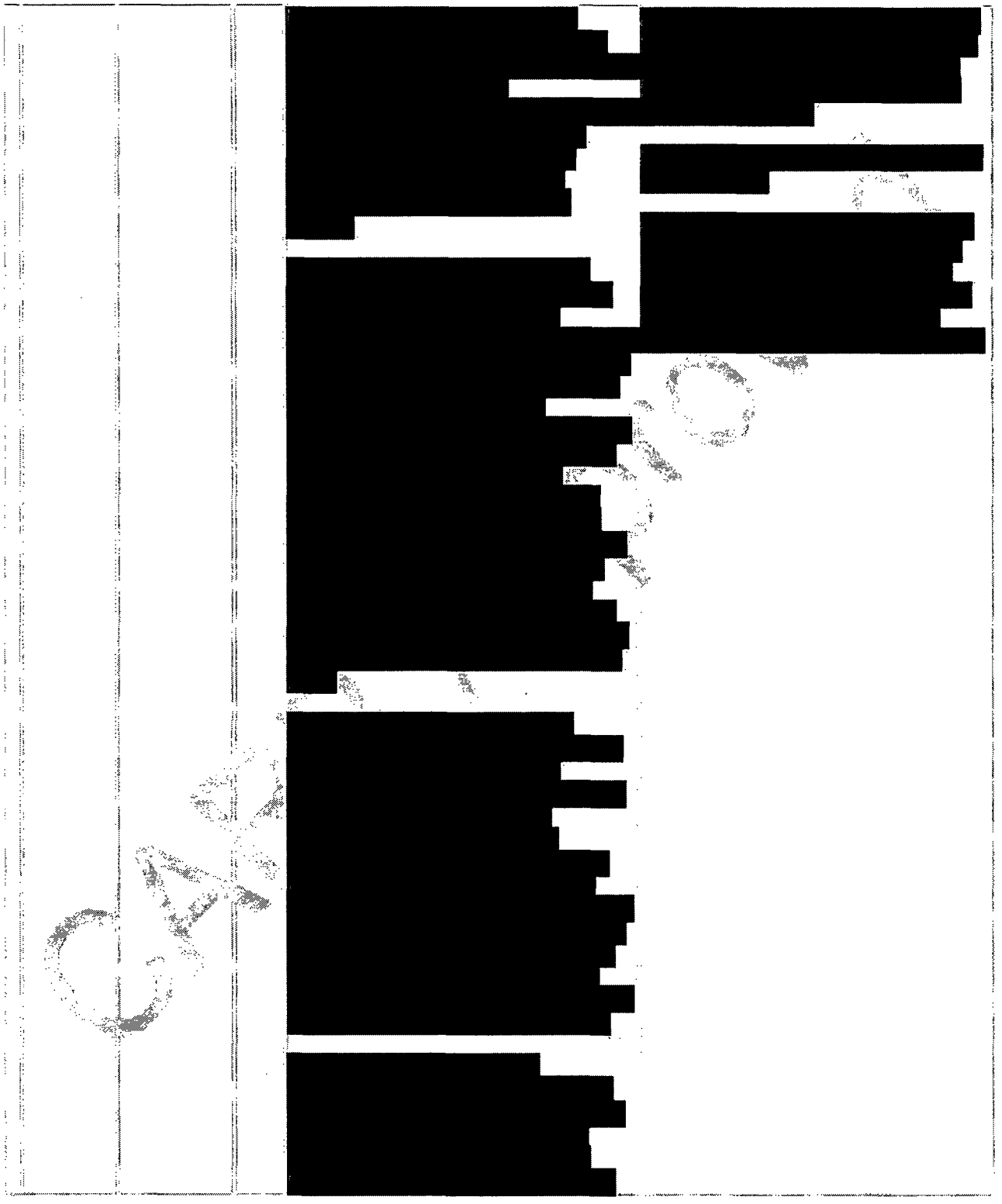

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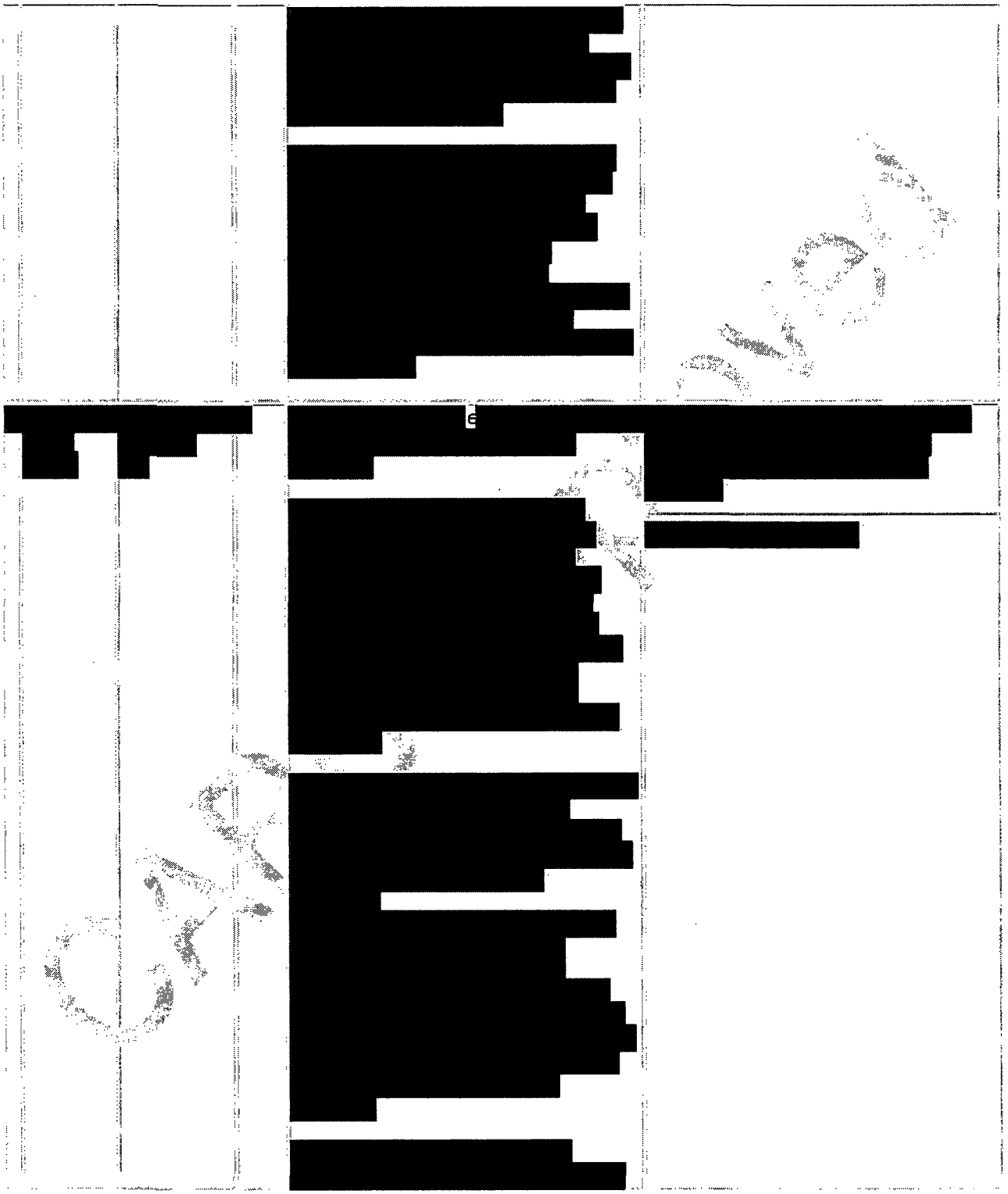

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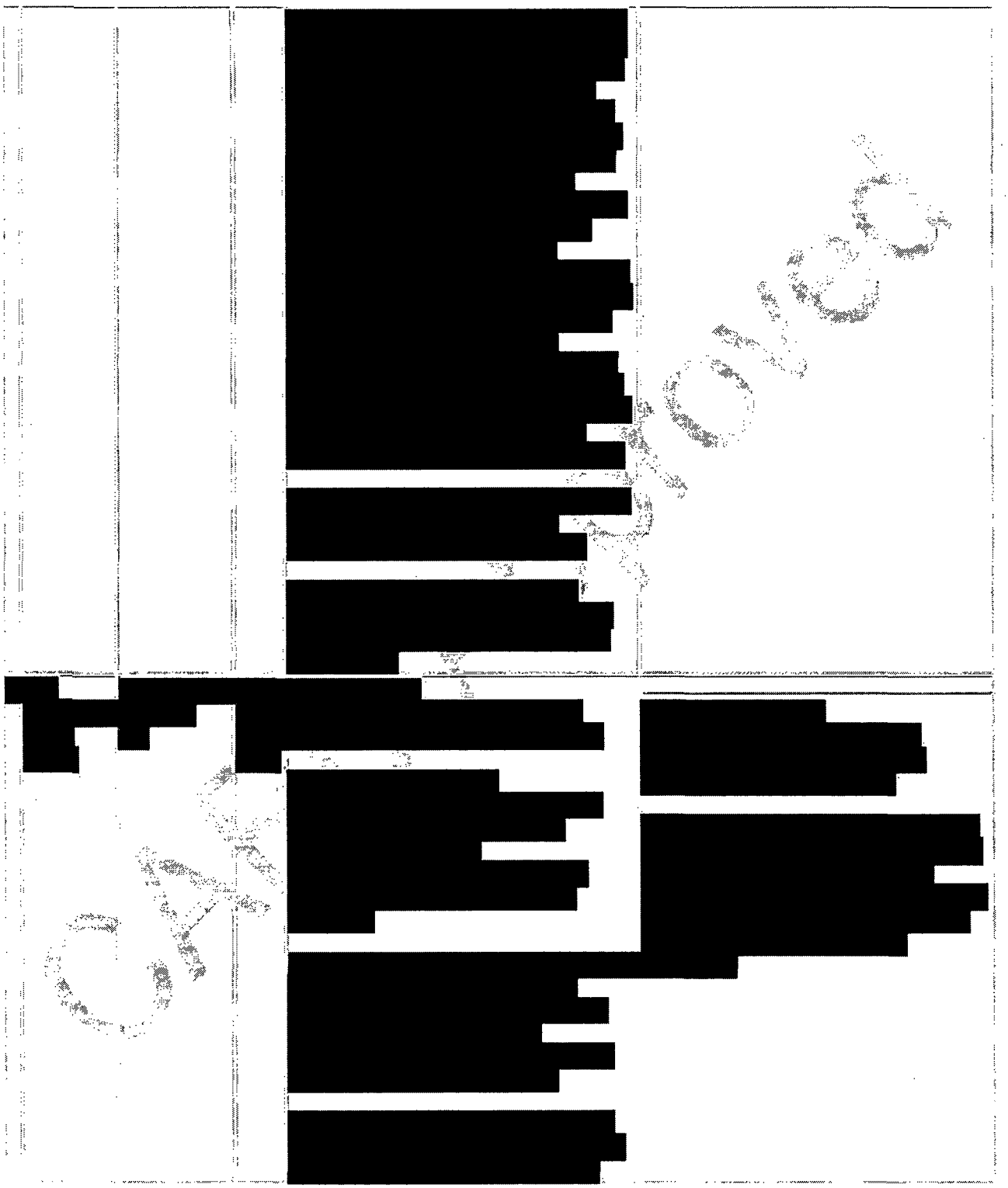

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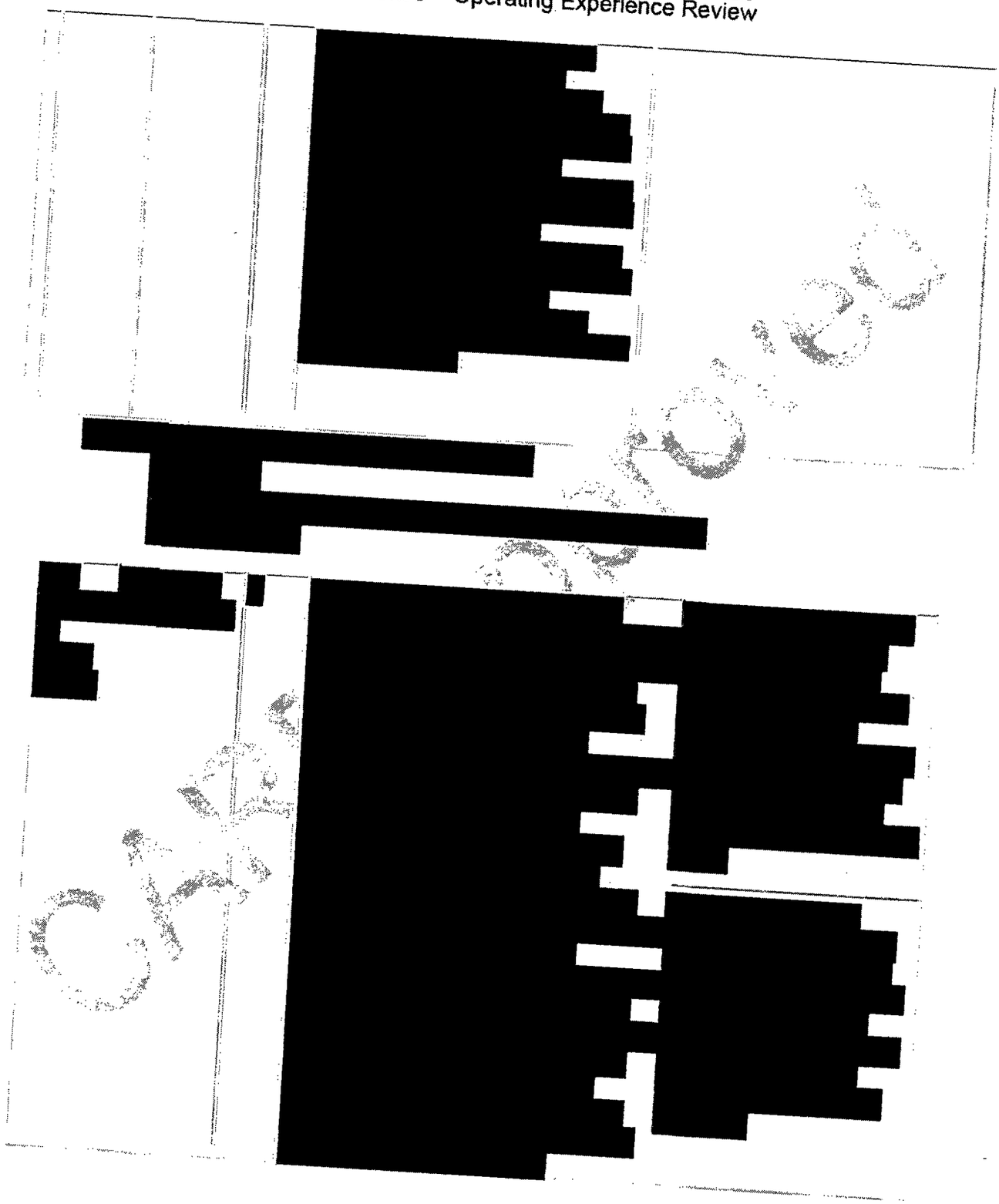

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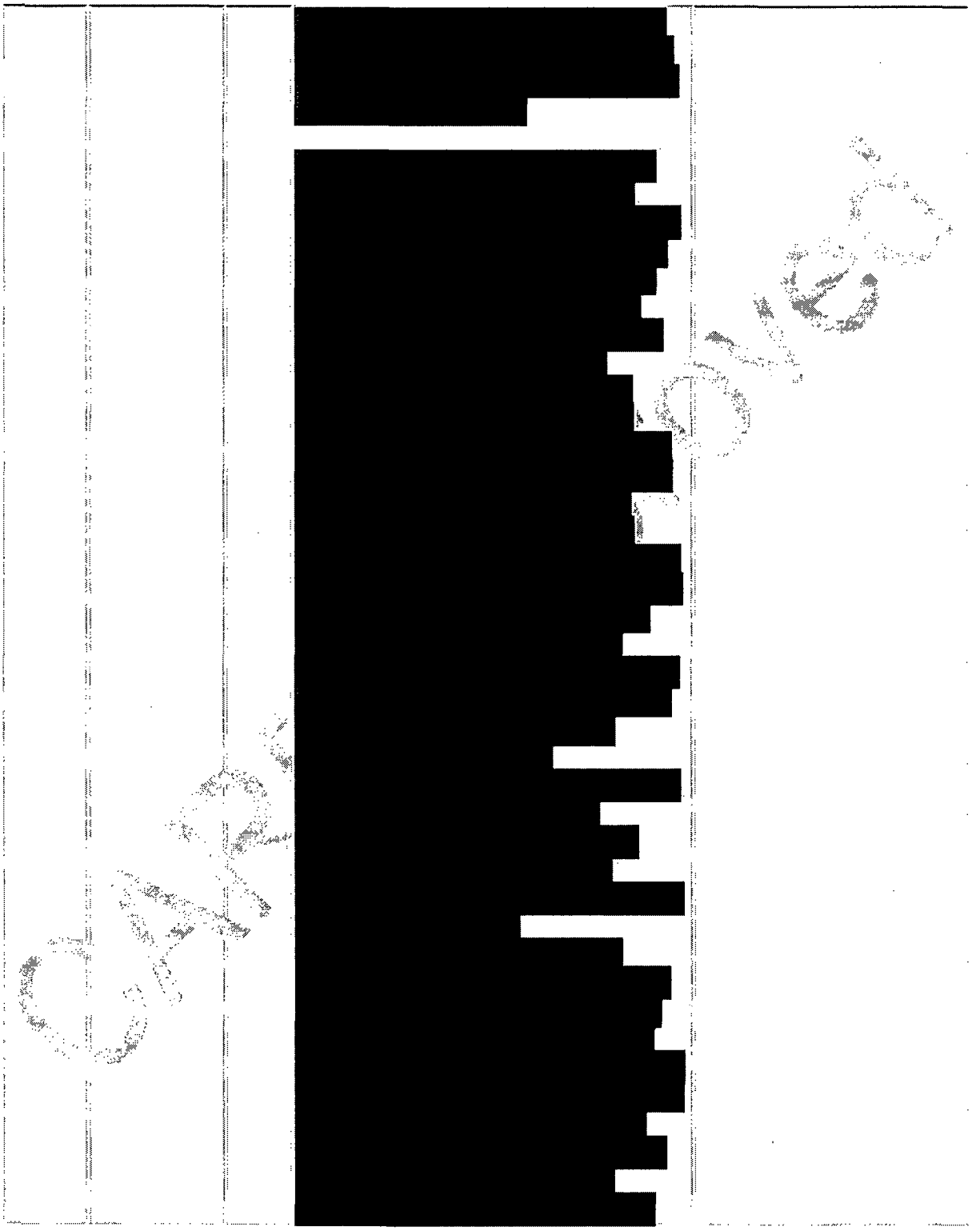

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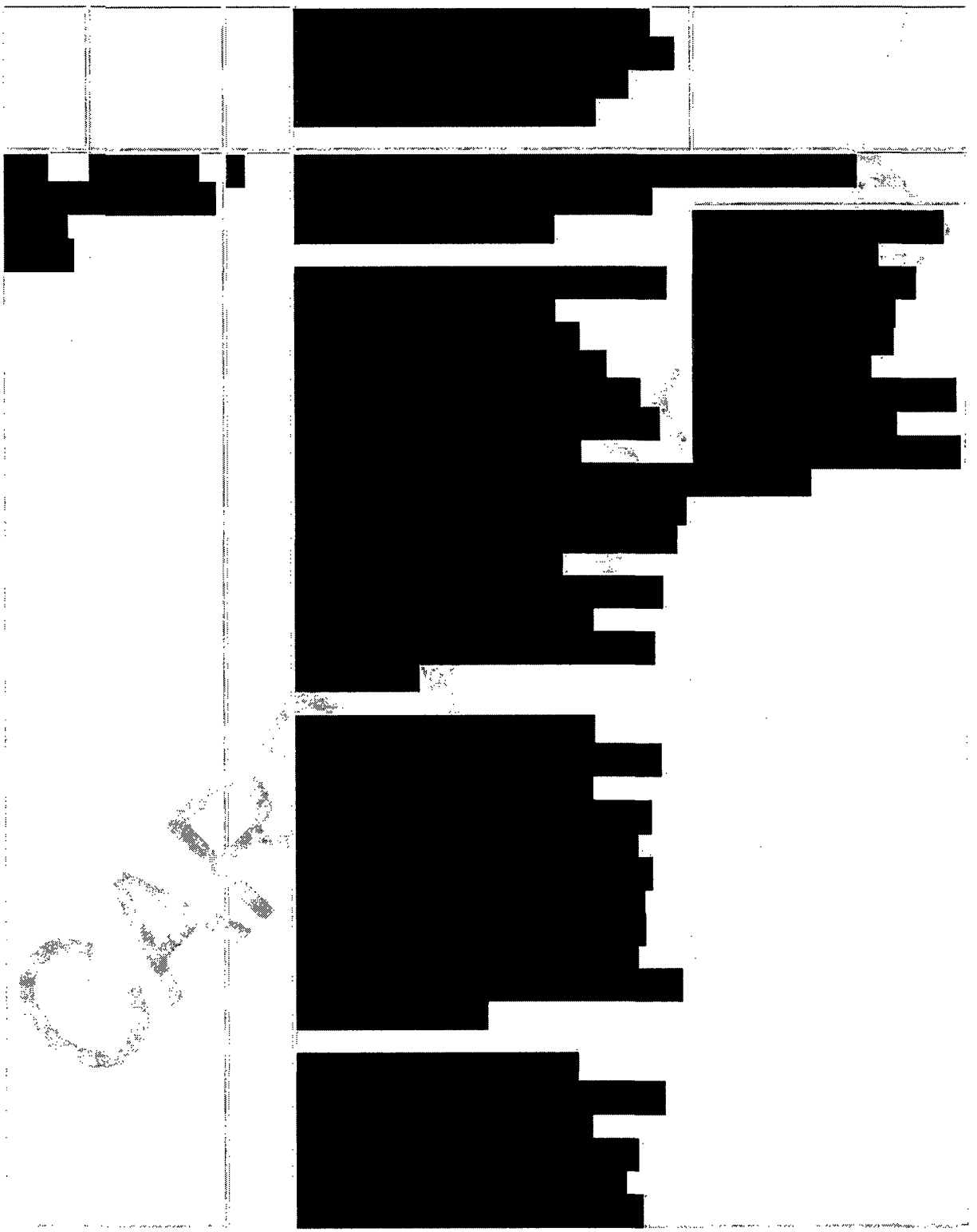

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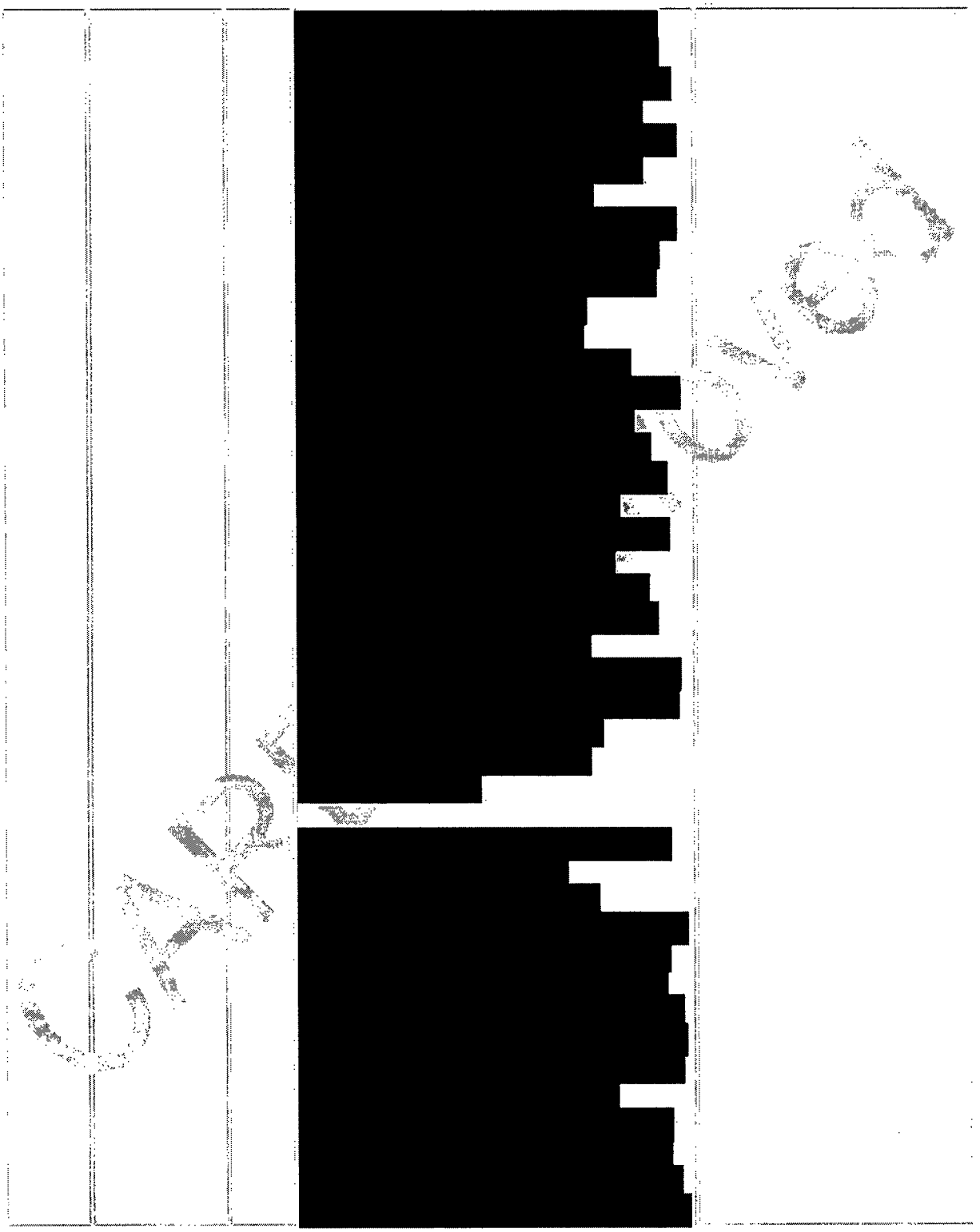

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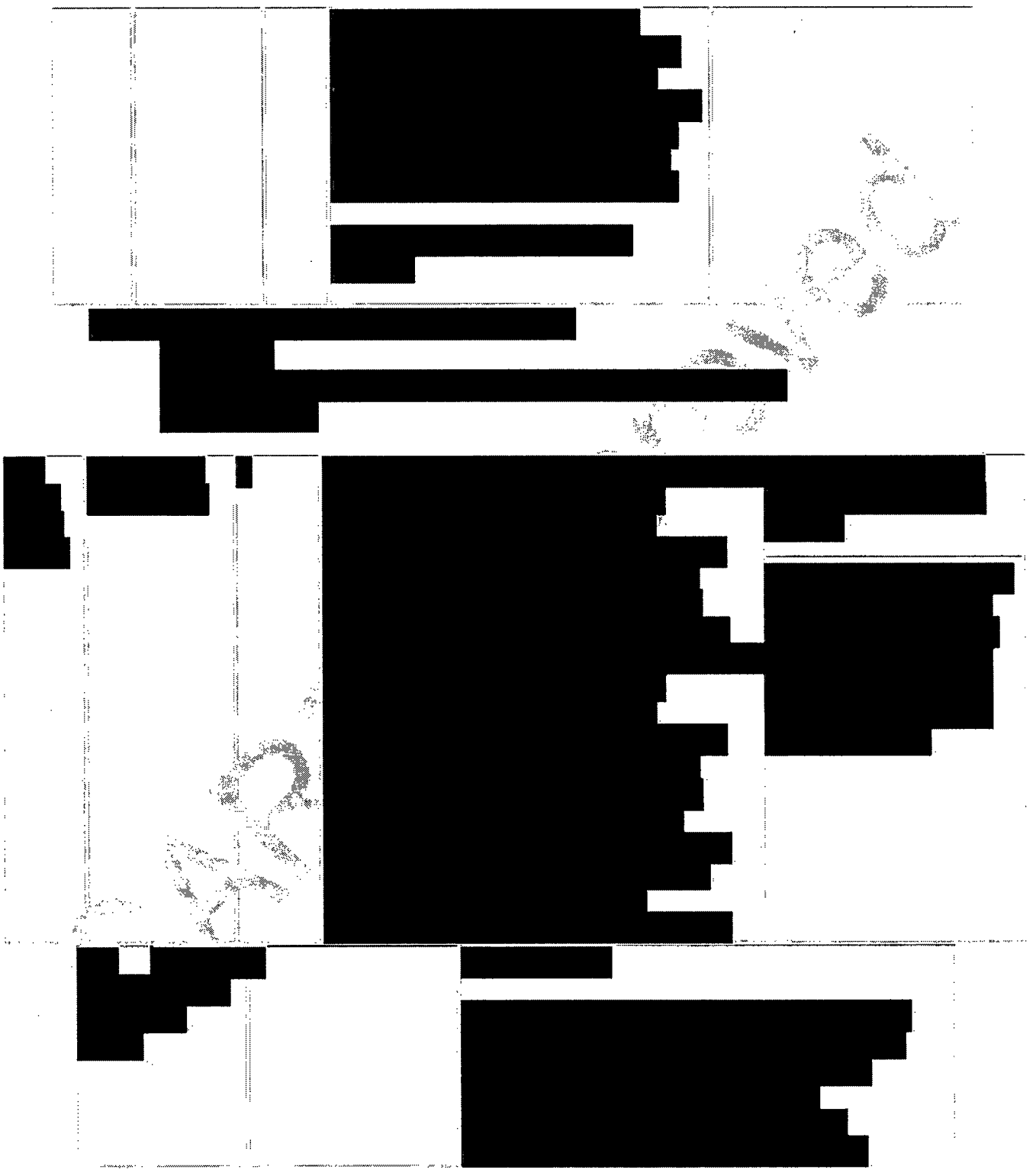
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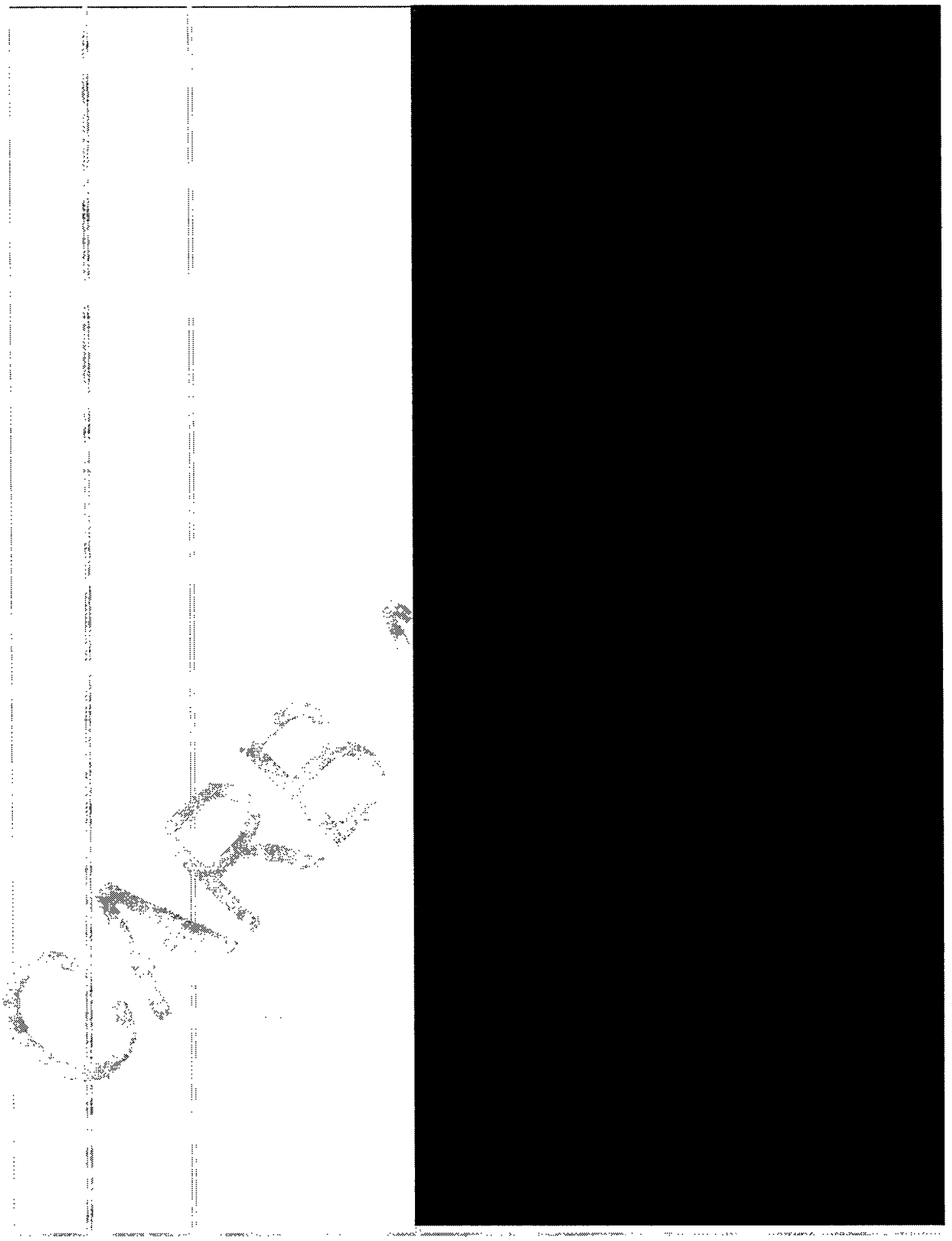

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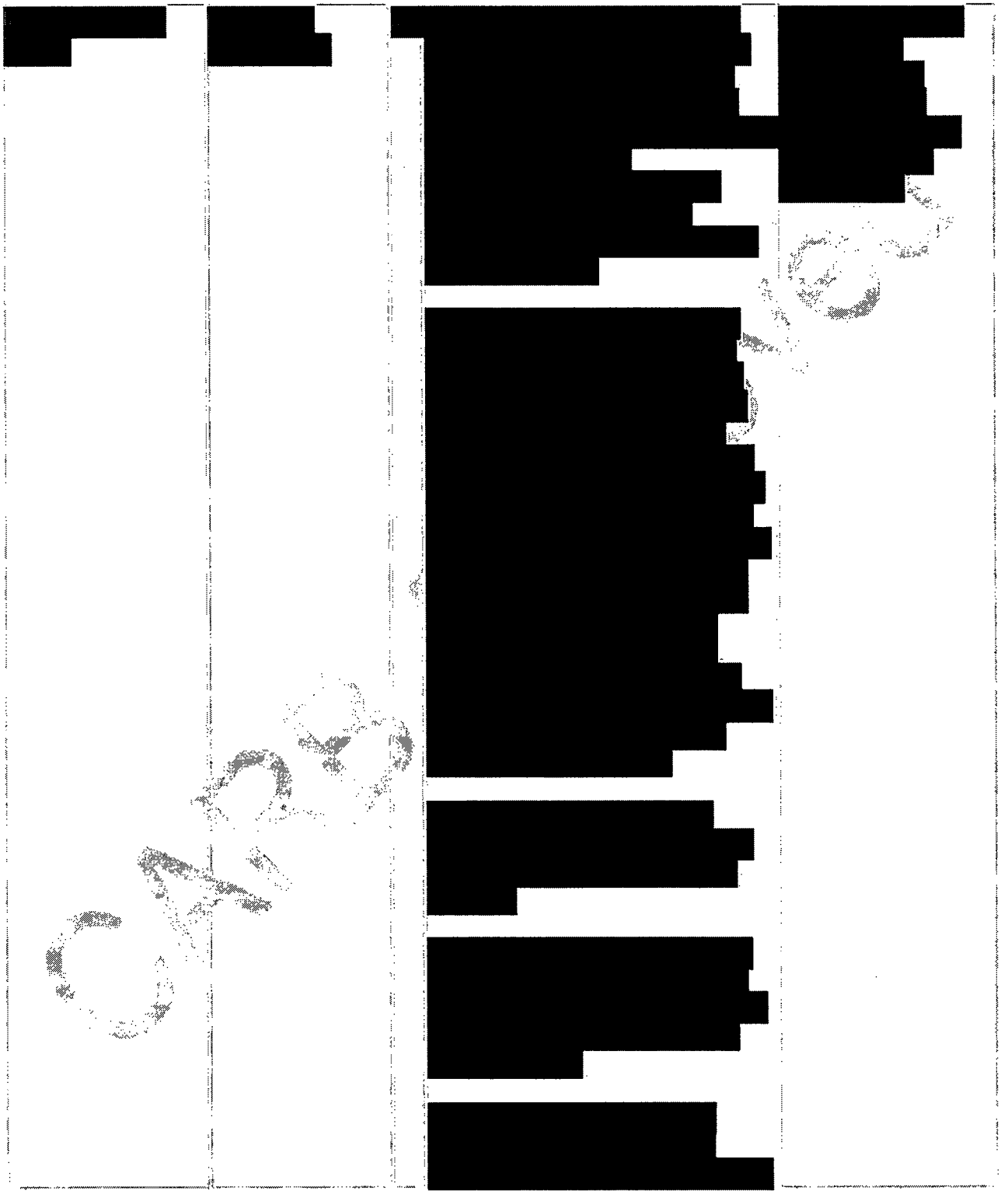

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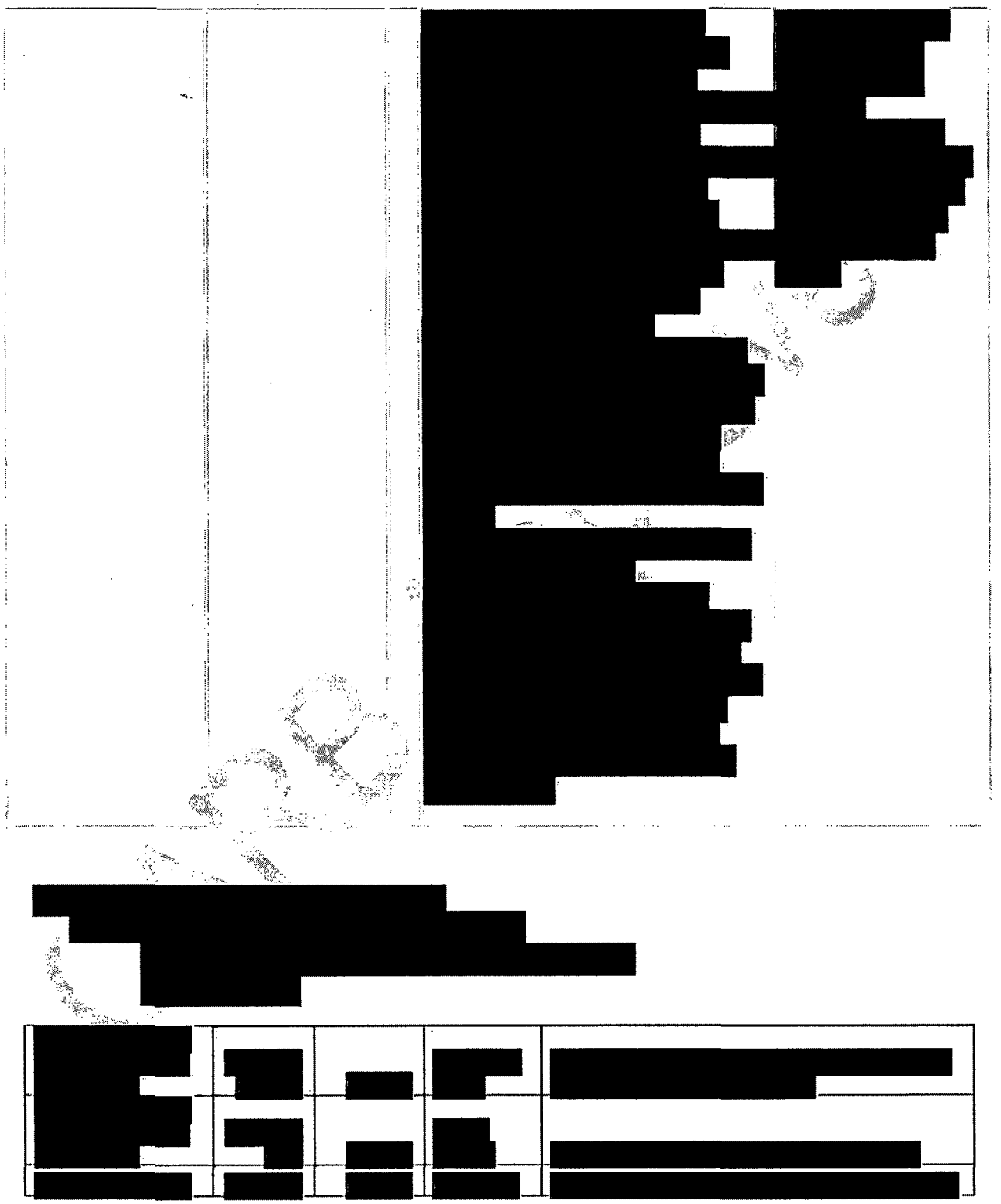
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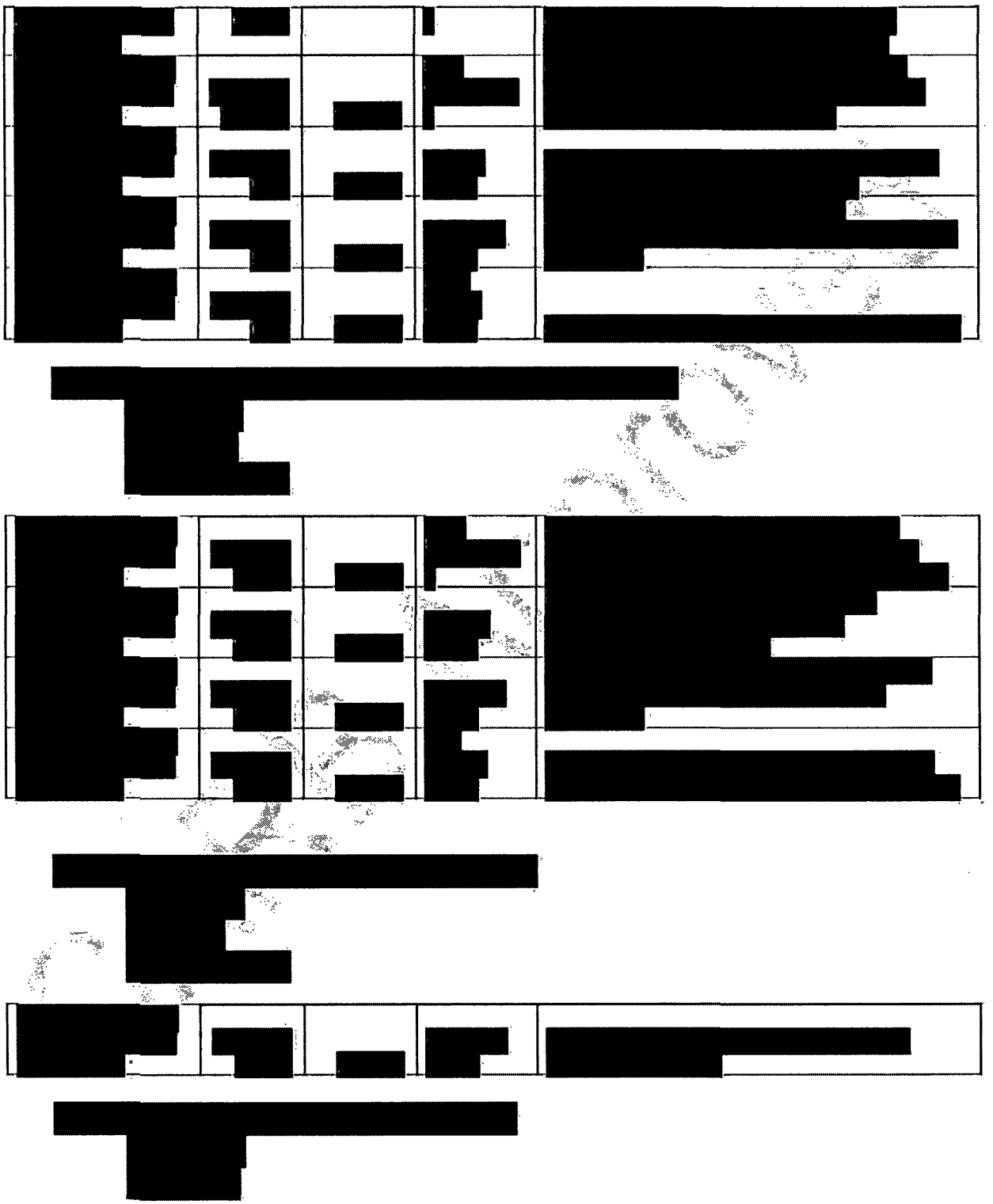

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