NRC Form 366
(9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/85

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Duane Arnold Energy Center	0 5 0 0 0 3 3 1	1 OF 0 9

TITLE (4)
Emergency Standby Diesel Generator Scavenging Air Blower Failure

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
0 6	1 7	8 4	8 4	0 2 1	0 0	0 7	0 6	8 4	None	0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9)		THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)			
N		20.402(b)	20.405(c)	50.73(a)(2)(iv)	73.71(b)
POWER LEVEL (10)		20.405(a)(1)(i)	50.36(c)(1)	50.73(a)(2)(v)	73.71(c)
0 5 8		20.405(a)(1)(ii)	50.36(c)(2)	50.73(a)(2)(vii)	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
		20.405(a)(1)(iii)	X 50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	
		20.405(a)(1)(iv)	50.73(a)(2)(ii)	50.73(a)(2)(viii)(B)	
		20.405(a)(1)(v)	50.73(a)(2)(iii)	50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER
James C. Smith, Technical Support Engineer	AREA CODE 3 1 9 — 8 5 1 - 7 3 0 8

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	
X	E K	B L 4 0	C 4 7 0	Y							

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE)	X NO				

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

At 2055 hours on June 17, 1984, the reactor was in run mode at approximately 58% power. A surveillance test for 'B' Standby Diesel Generator operability was being conducted when the diesel engine tripped on high crankcase pressure while loaded to approximately 2400 KW. An auxiliary operator observed smoke rising from burnt paint at the top of the scavenging air blower housing near the engine before the engine stopped. The cause of the burnt paint was later determined to be from blower internal friction. The plant entered a 7 day LCO per Technical Specification 3.5.G.1 and began surveillance testing for 'B' Standby Diesel Generator inoperability. Later investigations revealed that the scavenging air blower had seized. The failure was a result of the blower aluminum lobes rubbing the internal casing which caused substantial blower internal damage. While investigation into the root cause of the blower failure continued, the diesel engine and generator were inspected for further damage and a replacement blower was obtained from another utility. The diesel inspections were completed and the blower was installed before 7 days had elapsed, but preoperational testing revealed that the replacement blower's impellers were rubbing against the housing. Consequently, the plant initiated a controlled shut down on June 24. The replacement blower and a blower previously removed from the other diesel ('A') a month and a half before which had begun to rub were shipped to the manufacturer (Colt/Fairbanks-Morse Industries) for repair and failure analysis. The blower which caused the engine failure is also to be sent to Colt for failure analysis. One repaired blower was installed and the diesel was operable again on June 30.

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TEXT (If more space is required, use additional NRC Form 366A's) (17)

Description of Event

At 2055 hours on June 17, 1984, the reactor was in run mode at approximately 58% power. A routine surveillance test for 'B' Standby Diesel Generator Operability was being conducted when the diesel engine tripped from high crankcase pressure which was later attributed to scavinging blower failure. The diesel was loaded to approximately 2400 KW. An auxiliary operator observed smoke rising from burnt paint at the top of the scavenging air blower housing near the engine before the engine stopped. The cause of the burnt paint was later determined to be from blower internal friction. The diesel went from loaded condition to full stop in approximately 3 seconds. The only breaker which tripped during the event was the generator output breaker. The auxiliary operator immediately informed the Control Room. The diesel fuel supply was secured and the outside surface of the diesel was inspected for further damage. The plant entered a 7 day LCO in accordance with Technical Specification 3.5.G.1.

The scavenging air blower was removed from the diesel and was found to be seized and significantly damaged. This upper crank shaft driven blower furnishes intake air to the turbochargers and air receiver. It is loaded until the engine and turbocharger are running at near full load. When full load is reached, a damper routes the air fully to the turbochargers inlets and the blower is in the unloaded condition (pumping against no head). As designed, the blower consists of two intermeshed 3-lobed aluminum impellers with 24 to 32 mil clearances between the lobes and between the lobes and their aluminum housing. Both impeller shafts are attached to intermeshed gears. The bottom shaft is attached to a drive gear which is driven by a gear on the upper engine crank shaft. This crank shaft gear is attached to the crank shaft through a flexible coupling which contains leaf springs to absorb torsional shocks. An inspection of the blower and diesel engine revealed the following:

1. The blower lobes and housing were badly scraped at the ends and along the sides at both ends. The greater damage was at the engine end (in the direction of the thrust force), where pieces of the lobes had broken off. These pieces caused further damage within the blower.

2. Pieces of the blower lobes and powdered lobe and casing material were found at the intake and discharge sides of the blower, in the air receiver and in the turbochargers. Fine aluminum debris was found around the fuel injectors in the cylinders.

3. The blower driven gear was significantly damaged. It appeared that when the blower had seized, the drive gear mounted to the crank shaft ground the teeth of the blower driven gear. Other teeth on both gears were scored and chipped. There was evidence of high friction heat in the area of the sheared blower driven gear teeth.

4. All bearings were undamaged and fully oiled and were not considered to have contributed to the blower failure.

5. The disassembled blower was checked for evidence of foreign objects and/or foreign object damage. The casing, blower lobes, bearings and broken lobe debris were checked. In addition, the intake blower and air plenum and blower exit passages were checked for foreign debris. No direct blower damage or blower debris could be shown to be of a foreign nature. However, there were small pieces of what appeared to be gasket material and a small piece of rubber found in the diesel air cooler.

6. The crushed blower lobes were checked visually for material cracking in the non-damaged areas of the lobes. There was no indication of cracks found. (Cracks were found in the damaged portion of the lobes which we conclude is a result, rather than the cause, of the blower failure.)

7. Since the damaged blower lobes showed evidence of total lobe edge contact with either the blower housing or the other lobe, the potential of blower thermal expansion was investigated. This investigation included:

   a. The deisel generator design specification for maximum ambient temperature was checked. This was found to be 104 degrees F. The ambient temperature was measured in the 'A' diesel room on June 20 and found to be 108 degrees F. Furthermore, the blower casing temperature was found to be 117 degrees F. This factor alone is not sufficient to cause failure.

   b. An investigation was made into the effects of a lubrication modification which changed the pre-lube system into a continuous lubrication system. This modification added a larger oil heater which increased the oil temperature by 10 to 15 degrees. By manufacturer (Colt Industries) design, the lube oil temperature is maintained at 120 degrees or greater. Maintaining the oil at this temperature reduces oil viscosity, preventing the pre-lube pump from flooding the upper crankcase and reduces the potential for wiped bearings (which has occurred previously at DAEC).

   c. The blower temperature rise during normal operation was checked against the Colt original acceptance test data. There is a 53 degree rise at 100% generator loading and a 61 degree rise at 50% loading. This rise is an increasingly nonlinear function of blower differential pressure and ranges between 12 to 30 degrees per psi DP. The blower at 0% load operates at approximately 6 psi DP. Blower differential pressure is a decreasingly nonlinear function of generator load.

   d. Per Colt design, the maximum operating temperature of the blower is 250 degrees F. Above this temperature, blower lobe to lobe and lobe to casing clearances are reduced to unacceptable levels.

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e. The blower intake air is taken from the diesel Generator Room which is at relatively high temperatures.

8. A review of past blower maintenance and experience was conducted. In April of 1984, annual inspections of both diesel generators was conducted. During visual inspection of the 'A' diesel blower, minor rubbing was noted between the lobes and the casing. This 'A' blower was replaced at that time. As inspection of the 'B' blower showed no similar rubbing, the blower was not replaced. In April 1984, both blowers were originally supplied units which had been in-service approximately 10 years. The accumulated run times on each unit was approximately 650 to 775 hours.

9. Further inspections of the engine were conducted and details will be covered under "Corrective Actions".

While an investigation of the failure and an inspection of the diesel engine continued, a replacement blower was obtained from another utility and installed. Checks of lobe to lobe and lobe to housing clearances at accessible spots were made before installation with satisfactory results. However, during preoperational tests on June 24, 1984, it was discovered that the blower lobes were rubbing on the housing. Consequently, as repair was not possible within the 7 day LCO, the reactor was shut down in accordance with Technical Specification 3.5.G.1.

The replacement blower and the blower removed from the 'A' diesel were shipped to the manufacturer for repair and failure analysis. Colt representatives were also present when the seized blower was disassembled at the plant and this blower will also be sent to Colt for further analysis. One repaired blower was returned to the plant and was reinstalled on June 28. The diesel generator was tested and returned to service on June 30.

Root Cause of the Failures

A failure analysis was conducted by Iowa Electric and is currently being conducted by Colt Industries. The conclusion of Iowa Electric's study was that catastrophic failure of the 'B' diesel blower and the earlier rubbing of the 'A' diesel blower were probably from the same root cause. The root cause appears to be thermal induced creep of the aluminum blower impeller lobes. Actual measurement of the 'A' blower removed in April showed expansion of the lobes beyond as supplied dimensions. In the 'B' diesel blower, the creep occurred in the radial direction with the greatest creep occurring at the thrust end (engine end) due to additional thrust force. The enlargement of the impeller lobes due to creep when combined with normal enlargement due to thermal expansion caused the lobes to begin to rub. When the thrust end (at the side of the housing) began to rub, it is postulated that intense heat caused further thermal expansion (which was greatest in the axial direction) which caused the other end to begin rubbing. Analysis of the failures by Colt Industries is continuing and their analysis of the cause or causes will be forthcoming to Iowa Electric. (An updated LER will be provided in the event this analysis reveals significant additional information.)

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In addition:

1. The modification of the pre-lube system appears to have increased the room temperature and blower temperature by 10 to 15 degrees F. The diesel generator engine coolant temperature shows about a 5 degree increase. The pre-lube modification and its effect on the room temperature is felt to be a contributor to the creep phenomenon but not a major cause.

2. Since the blower housing temperature was measured and found to be 117 degrees F, the blower lobe temperature could be expected to be 120 degrees or higher. Additionally, Colt data indicates that during blower startup, the temperature increase before diesel loading can be as great as 100 degrees. Therefore, the temperature reached in the blower with the diesel not loaded can be as high as 220 degrees F. It is felt that running the diesel in the unloaded condition has the dominant effect on the rate of creep.

Concerning the case of the replacement blower rubbing on its housing, tests at Colt facilities concluded that the blower was damaged in transit or storage prior to arrival at the plant. A small indentation in the blower casing was found which caused one blower lobe to rub in a localized area. This was not observed during receipt inspection and installation at the plant because the area was so small. Also, the interference would not have been seen unless the blower lobes were in a particular configuration. The damage had to occur after leaving the Colt facility because Colt records show that the blower was checked and operationally tested just prior to shipping.

It is Iowa Electric's conclusion, therefore, that creep which occurred over 10 years of blower service is the root cause of the first two events. Intrusion of a foreign object cannot be ruled out, especially considering the small amounts of foreign matter found. However, the damage observed in the seized blower and the damage in the 'A' diesel blower do not appear to support this theory. Iowa Electric has concluded, however, that both events are caused by a time-dependent phenomenon. With this in mind, Iowa Electric is performing the corrective actions identified below:

Corrective Actions

The 'B' diesel engine was inspected as follows to assure that debris from the failed blower and the shock from the seizure of the blower did not further damage the engine:

1. The flex coupling on the upper crank shaft was inspected. Although there was no damage found, the coupling was replaced. The drive gear on the crankshaft driving the blower was replaced.

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2. The lube oil strainer was inspected and cleaned. No aluminum debris was found. An oil sample was taken and sent for analysis. The oil was also drained and replaced. The crankcase oil separator drain tube was inspected and found satisfactory.

3. The vertical drive coupling linking the upper and lower crank shafts was inspected and found undamaged.

4. All timing gears and the timing chain were inspected and found undamaged and the timing was unchanged.

5. All inlet air ducting, cooler, and exhaust ports were inspected and cleaned.

6. The blower housing mounting bolts and the engine anchor bolts were inspected for signs of stress and found satisfactory.

7. The pistons and cylinder liners were inspected and found in satisfactory condition.

8. Both turbochargers were cleaned and inspected. Rotating element damage was found resulting from debris lodged in the intakes which interferred with the turbochargers' operation. The turbochargers' rotating elements were replaced. The nozzle rings were cleaned.

9. Correct operation of the air inlet check valves was verified.

10. The main and connecting rod bearings were inspected and found in satisfactory condition.

11. The torsional damper was inspected and found in satisfactory condition.

12. The generator was visually inspected and found in satisfactory condition. The generator windings were megger tested and found satisfactory.

13. The blower inlet filters were replaced.

Surveillance testing and maintenance procedures will be revised in an effort to monitor the progress of creep and to eliminate other possible failure causes:

1. Per vendor recommendations, our routine maintenance and annual diesel inspection has not previously included any measurement of blower clearances. These blower checks had been visual only. After receiving the 'B' repaired replacement blower, measurements of lobe to lobe and lobe to housing clearances were made prior to and subsequent to blower installation, and following diesel generator operation. Pre-operational testing included recording blower inlet and outlet temperatures and pressures by temporarily installed instrumentation. These clearance checks will be repeated quarterly for the first year to establish baseline information and will be performed yearly to trend these parameters. Significant decreases in lobe clearances will result in blower replacement. (Similar baseline data has been obtained for the recently installed 'A' blower.)

2. As foreign material cannot be eliminated as a contributing cause, cleanliness and material control in the intake plenum and blower will be augmented and assurances will be made that the filters are intact with no openings.

Operational procedures and design changes are under consideration. The long term nature of the problem enables Iowa Electric to thoroughly study the consequences of these actions.

1. Surveillance test procedures may be revised to reduce the amount of time the diesel engine operates in an unloaded condition (which results in the highest temperatures in the blower). Furthermore, startup and cool down procedures may be modified in an effort to keep the blower operating temperatures as low as possible.

2. Design and operational changes may be made in an effort to lower the ambient temperature of the diesel rooms and hence the intake air to the blower.

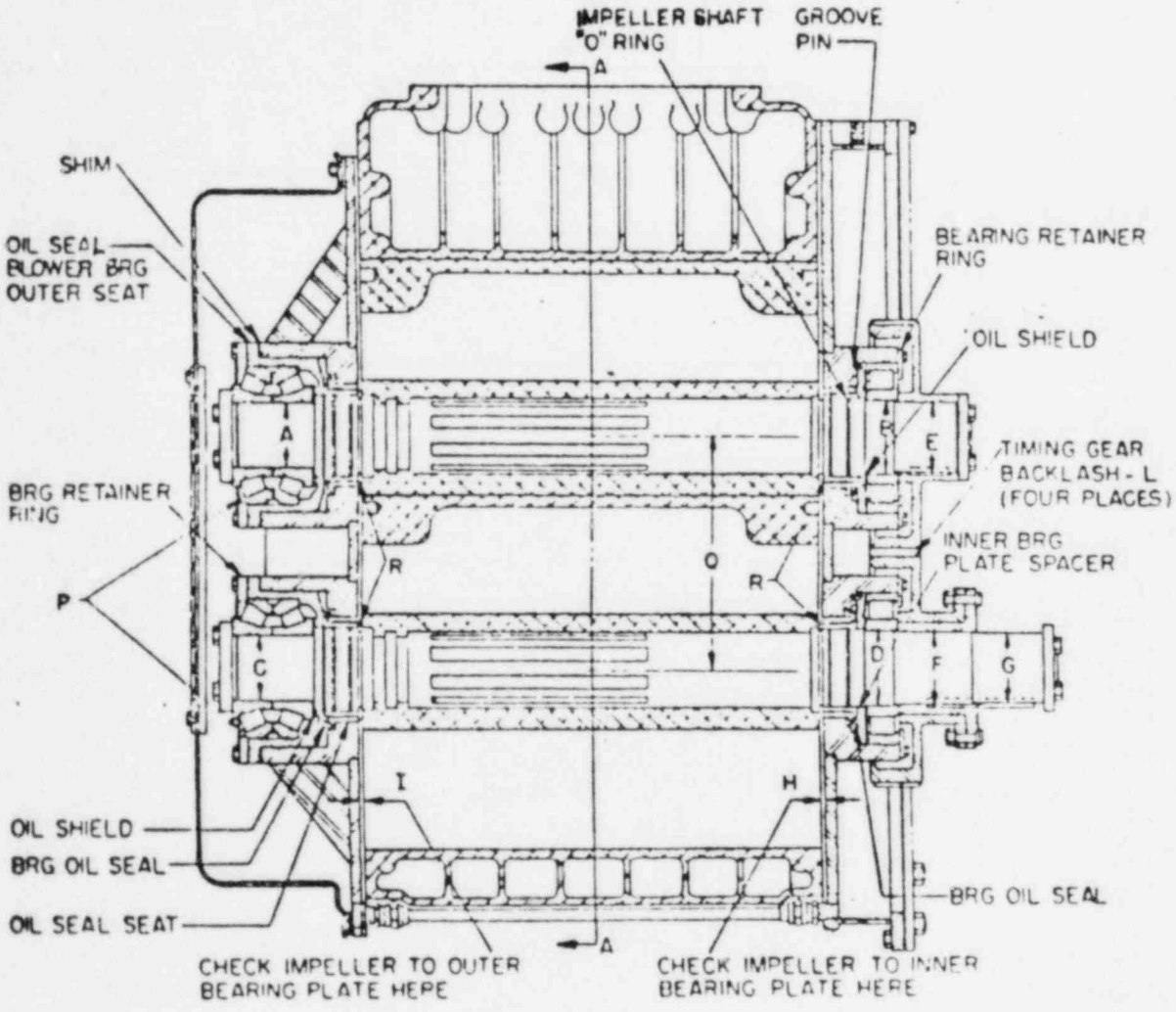
Additionally, Colt and Iowa Electric engineering studies are continuing with the help of outside consultants to definitely determine the mode of these failures and to improve procedures and design to avoid future failures.

Conclusions

The blowers at DAEC have experienced earlier than expected end of life failure (approximately 10 years). Our present belief is that the failure mechanism is time and temperature dependent plastic deformation. Annual inspections and augmented periodic inspections have been instituted to measure the components for the purpose of quantifying the rate of creep and instituting preventive maintenance before failure. Engineering efforts have also been initiated to lower ambient and peak diesel temperatures in order to extend blower life. As foreign material cannot be eliminated as a contributing cause, augmented cleanliness practices have also been implemented. Efforts will continue, including analysis by the manufacturer, to finalize the failure analysis and improve DAEC's ability to predict approaching failures and take prior preventive measures. DAEC has also communicated with other utilities through "Network" and advised them of our experience.

We believe that these activities will prevent diesel generator inoperability which results from blower failure of the type experienced at DAEC.

SCAVENGING AIR BLOWER - SIDE VIEW



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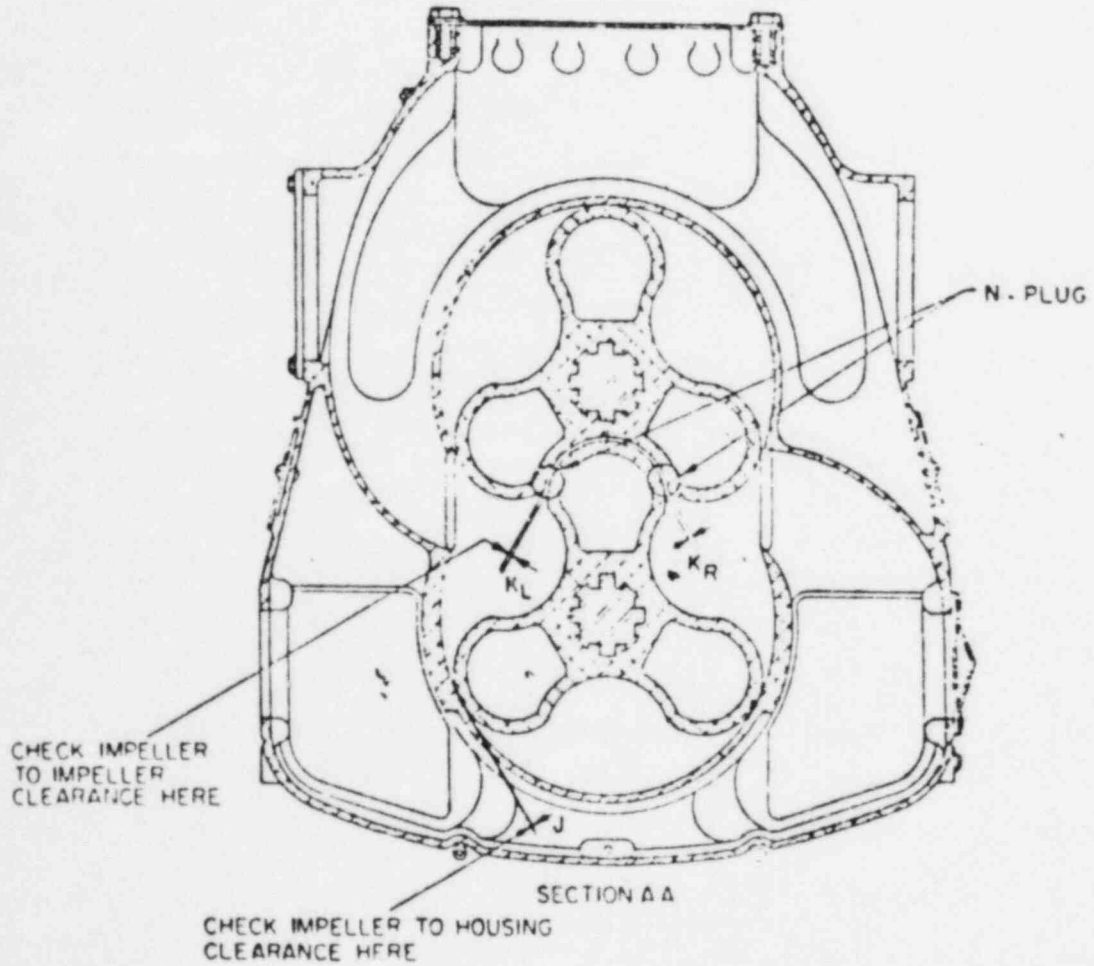
SCAVENGING AIR BLOWER - FRONT VIEW



Iowa Electric Light and Power Company

July 6, 1984
DAEC-84-436

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, D. C. 20555

Subject: Duane Arnold Energy Center
Docket No. 50-331
Op. License DPR-49
Licensee Event Report No. 84-021

Gentlemen:

In accordance with 10 CFR 50.73 please find attached a copy of the subject Licensee Event Report.

Very truly yours,

Daniel L. Mineck
Plant Superintendent - Nuclear
Duane Arnold Energy Center

DLM/JCS/kp

attachment

cc: Mr. James G. Keppler
Regional Administrator
Region III
U. S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, IL 60137

NRC Resident Inspector - DAEC

File A-118a

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