

05-48-90

GEORGIA POWER  
POWER GENERATION DEPARTMENT  
VOGTLE ELECTRIC GENERATING PLANT  
TRAINING LESSON PLAN

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TITLE:	EMERGENCY DIESEL GENERATOR AUXILIARIES: COMBUSTION AIR AND EXHAUST	NUMBER:	LO-LP-11103-06-C
PROGRAM:	LICENSED OPERATOR	REVISION:	6
SME:	BRIGDON	DATE:	2/28/90
APPROVED:	<i>Robert J. Brown</i>	DATE:	2/28/90

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INSTRUCTOR GUIDELINES:

- I. FORMAT
  - A. Lecture with visual aids
- II. MATERIALS
  - A. Overhead projector
  - B. Transparencies
  - C. White board with markers
- III. EVALUATION
  - A. Written or oral exam in conjunction with other lesson plans
- IV. REMARKS
  - A. NONE

FOR INFORMATION ONLY

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Licensed Operator Objectives for this lesson plan can be found in the Licensed Operator System Master Plan Section 2.3 (Qualification Signoff Criteria)

Latest Revision of

Cluster 11 DIESEL GENERATOR

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## REFERENCES:

1. Plant Vogtle Procedures:
  - 13145 "Diesel Generator"
  - 13146 "Diesel Generator Fuel Oil Transfer System"
  - 14980 "Diesel Generator Operability Test"
  - 13427 "4160 VAC 1E Electrical Distribution System"
  - 17035, Annunciator Response Procedures
  - 17038, Annunciator Response Procedures
2. Technical Specifications:
  - 3.8.1 Electrical Power Systems, AC sources
3. "Standby (Emergency) Diesel Generator," Vogtle Training Text Chapter 16C
4. Plant Manual Chapter 23
5. P&IDs, Logics and Other Drawings
  - Piping and Instrument Diagrams
  - 1X4DB170-1
  - 1X4DB170-2
  - Vendor Drawings
  - AX4AK01-27 (Lube Oil)
  - AX4AK01-26 (Jacket Water)
  - AX4AK01-29 (Starting Air)
  - AX4AK01-28 (Fuel Oil)
  - Control Logic Diagrams:
  - 1X5DN107-1 (DG Fuel Oil System)
  - 1X5DN107-2 (DG Unit Engine)
  - 1X5DN107-3 (Generator)
  - Elementary Diagrams
  - 1X3D-BH-G03C
  - 1X3D-BH-G03D
  - 1X3D-BH-G03E
  - 1X3D-BH-G03F
  - 1X3D-BH-G03G
  - 1X3D-BH-G03H
  - 1X3D-BH-G03I
  - 1X3D-BH-G03J
  - One Line Diagrams
  - 1X3D-AA-A01A
  - 1X3D-AA-K01A
6. Vendor Manuals
  - AX4AK01-509
  - AX4AK01-510
  - AX4AK01-563

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**REFERENCES:**

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7. FSAR: 8.3, 9.5.4, 9.5.5, 9.5.6, 9.5.7, 9.5.8
8. OAP Commitments: none
9. Instructional Units: none
10. Transparencies:
  - LO-TP-11103-001 Lesson Objectives
  - LO-TP-11103-002 Intake and Exhaust System

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**III. LESSON OUTLINE:**

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NOTES

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**I. INTRODUCTION****A. Overview**

1. This lesson describes how air is supplied to the diesel engine for combustion, and how it is exhausted from the combustion chambers. This lesson treats the combustion air and exhaust as a component of the diesel generator system
2. Present lesson objectives

LO-TP-11103-001  
Write on board**B. The lesson is presented in the following sequence:**

1. Design bases
2. Functions
3. Component description
4. Controls and instrumentation
5. System operation
6. System interfaces
7. Summary

**II. LESSON PRESENTATION****A. General Overview**

1. The purpose of the combustion air and exhaust system is to provide filtered cooled compressed air for combustion, and a means for removal of exhaust products
2. System Safety Design Bases
  - a. The diesel generator combustion air intake and exhaust system is capable of supplying adequate combustion air and disposing of resultant exhaust products to permit continuous operation of both diesel generators for each unit to 110 percent of nameplate rating
  - b. The diesel generator combustion air intake and exhaust system is designed to remain functional during and after a design basis earthquake

## III. LESSON OUTLINE:

NOTES

- c. The air intake and exhaust system is designed so that a single failure of any component, assuming a loss of offsite power, cannot result in complete loss of the standby power source
- d. The diesel generator combustion air intake and exhaust system is capable of being tested during plant operation in accordance with 10 CFR 50, General Design Criterion 18

## B. Functions

- 1. The functions of the combustion air and exhaust system are to:
  - a. Filter the air being supplied to the engine
  - b. Silence air being supplied to the engine, and exhaust from the engine, to minimize noise levels in the building
  - c. Increase engine efficiency by compressing the air being supplied for combustion, then cooling it through combustion air coolers
  - d. Isolate when required on an engine trip by the shutting of the combustion air damper for each bank

## C. Component Description and Basic Flowpath

LO-TP-11103-002  
Objective 2

- 1. Intake Air Filter
  - a. Removes dust and grit from combustion air before it enters the engine
  - b. Oil bath filter (cycoil type)
    - 1) 109 gallons of oil
    - 2) 24,800 scfm rated flow
  - c. Located on 2nd level of DG Building in enclosure
  - d. Mist eliminator pads and rain shield is provided to remove oil and moisture from filtered air
- 2. Intake Silencers

## III. LESSON OUTLINE:

## NOTES

- a. Minimize DG Bldg. noise level
  - b. Two tubular duct silencers per unit
  - c. Rated flow 14,030 scfm each
3. Turbochargers
- a. Combination exhaust driven turbine/centrifugal blower units, on a common shaft
  - b. Two, one for each bank
  - c. Exhaust turbine - function is to cause the blower to turn
  - d. Blower - function, to pressurize fresh, filtered combustion air in order to put more air into the cylinders than they would otherwise have, to increase engine efficiency
  - e. Exhaust gas flow  $\leq$  13,500 scfm
4. Combustion Air Intercooler
- a. One for each bank
  - b. Jacket water cooling medium
  - c. Removes heat of compression from turbocharged air
  - d. 900 gpm jacket water cooling flow
5. Combustion Air Supply Dampers
- a. Close on engine trip to isolate supply of combustion air
  - b. Two - one per engine bank, cylinder actuator
  - c. Spring pressure to open, air pressure to close cylinders
  - d. Shut rapidly (less than approx. 1 second) on an engine overspeed - 60 psi regulated air from 250 psi air supply
- Similar to auto radiator
- Overspeed response quickened as result of Grand Gulf DG runaway, overspeed and



## III. LESSON OUTLINE:

## NOTES

- e. Shut slowly on other engine trips (other than overspeed) - shutdown air supplied through engine pneumatic logic in control panel
6. Piping and Distribution
- a. Intake manifold
- 1) Distributes combustion air for supply to each cylinder
    - a) Runs beneath catwalks, each bank
    - b) Inlet to each cylinder
    - c) Has small (1/4") pipe coming from across plate on bottom (front and rear)
      - (1) Used to blow down intake manifold when performing cylinder moisture checks
      - (2) Water leaks into intake manifold detected by opening manifold drain valves (4 per manifold)
      - (3) Water indicates jacket water leakage and should be brought to the attention of the USS
      - (4) Water injected into the cylinder during subsequent operations could result in cylinder damage
- b. Exhaust manifold
- 1) Routes exhaust gases from each cylinder to a common pipe for exhausting to that bank's turbocharger turbine
  - 2) Exhaust manifolds on engine top, between banks
  - 3) Exhaust piping after turbochargers is insulated and joins to one pipe
- resulting engine damage  
approx. 3 to 4 seconds

## III. LESSON OUTLINE:

NOTES

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7. Exhaust Silencer
- a. Minimizes DG building noise level
  - b. One horizontal silencer per D/G, 27,000 scfm @ 900° F
  - c. Located in room next to air intake filter
- D. Controls and Instrumentation
1. No active controls (start/stop switches)
  2. Combustion air supply dampers
    - a. Overspeed - shut rapidly (less than approx. 1 second) Objective 4
      - 1) 250 psi air regulated to 60 psi
      - 2) Supply piping more direct than for normal trips
    - b. Other engine trips - dampers shut more slowly, approx. 3 or 4 seconds
      - 1) 60 psi air
      - 2) Supplied through pneumatic logic in engine control panel
  3. Associated Diesel Generator Trips and Alarms
    - a. Low Press Turbo Oil - Right ( $\leq$  20 psig) Alarm
    - b. Low Press Turbo Oil - Left ( $\leq$  20 psig) Alarm
    - c. Trip - Low Press Turbo Oil ( $\leq$  15 psig) Trip
    - d. Vibration Trip - one vibration detector on each turbo, plus two engine vibration detectors Trip
    - e. Turbocharger associated trips not available on emergency starts
  4. Local Engine Panel Objective 3  
(partial)
    - a. Combustion air pressure
      - 1) Intake manifold pressure supplied by turbos

- 2) LEFT-TEST-RIGHT selector, one gauge
  - 3) Proportional to load
  - 4) Differences in bank pressures can indicate turbocharger problems
- b. Doric Trendicator - (Thermocouples)
- 1) Thermocouples 1-8 left bank cylinders
  - 2) Thermocouples 9-16 right bank cylinders
  - 3) Thermocouples 17, 18 turbocharger stack exhaust temperatures

#### E. System Operation

##### 1. Principle of turbocharger operation:

Objective 1

- a. Turbocharger turbine receives exhaust, and spins
  - b. As exhaust turbine spins, so does its bearing supported shaft
  - c. At the other end of the shaft, the blower wheel pulls fresh air in, compresses it, and discharges it to an intercooler
  - d. The turbochargers pressurizes the intake manifold
  - e. Amount of air being pulled in depends on flow of exhaust being discharged, so turbocharger speed will vary with engine load due to the heat of combustion
  - f. Scavenges exhaust from cylinder after exhaust stroke
  - g. Fills cylinder with air charge of high density on intake stroke
- ##### 2. Ensuring Turbocharger Reliability
- a. Turbocharger bearings
    - 1) Bearing receives drip lube while engine is in standby

## III. LESSON OUTLINE:

## NOTES

- |   |  |  |
|---|--|--|
| <ul style="list-style-type: none"> <li>a) From lube oil keep warm system</li> <li>b) Drip or very small stream</li> <li>c) Drip visible in sight glass for each turbo</li> </ul>  | <ul style="list-style-type: none"> <li>2) Manual pre-lube for planned starts via lube oil keep warm pump supplying oil</li> <li>3) Engine running, oil supplied to turbocharger by main engine lube oil</li> </ul> | <p>Approx. .35 gph</p>   |
| b. Turbocharger cooling   |  |  |
| <ul style="list-style-type: none"> <li>1) Engine running - jacket water system</li> <li>2) Engine standby - jacket water keep-warm helps remove residual heat in turbocharger after the engine has shut down</li> </ul>   |  |  |
| c. Monitoring of turbocharger inlet temperature   |  |  |
| <ul style="list-style-type: none"> <li>1) 1200<sup>o</sup>F to turbocharger turbine inlet temperature limit</li> <li>2) Not directly read, so use a <u>cylinder</u> temperature limit of 1050<sup>o</sup>F max.</li> <li>3) May approach this on 110% load testing</li> <li>4) Each cylinder should be less than <math>\pm 50^{\circ}\text{F}</math> from average of all cylinders</li> </ul> | <ul style="list-style-type: none"> <li>2) Intake manifold pressure differences between banks can indicate a turbocharger beginning to fail</li> </ul>  | <p>PEO does this Objective 3 (partial)</p> <p>Slow response of thermocouples on each engine stroke. TCs won't show peak temps. Also, engine cly. cools between strokes</p> |
| d. Intake manifold pressure differences between banks can indicate a turbocharger beginning to fail   |  |  |
| 3. Importance of proper oil level in Air Intake Filter  |  |  |
| a. Level too high, could be from:   |  |  |
| <ul style="list-style-type: none"> <li>1) Water in the reservoir</li> <li>2) Dust displacing oil level</li> </ul>   | <p>Objective 3 (partial)</p> <p>1"-2" sludge on bottom expected</p>  |  |
| b. Level low or none - Dust enters the engine cylinders and can cause damage  |  |  |
|   |  | <p>Premature wear</p>  |

III. LESSON OUTLINE:

NOTES

4. DG building Located away from gas storage facilities preventing gas intake

CO<sub>2</sub> - 260'  
H<sub>2</sub> - 600'

F. System Interfaces

1. Diesel Generator Lube Oil
  - a. Keep warm
  - b. Main
2. Diesel Generator Jacket Water Cooling
  - a. Keep warm
  - b. Main
3. Diesel Generator Pneumatic Controls Protective Tripping

III. SUMMARY

A. Review Objectives

1. DESCRIBE THE OPERATION OF THE EDG TURBOCHARGER  
See Sections II.C.3 and II.E.1
2. DESCRIBE THE BASIC FLOWPATH OF THE EDG COMBUSTION AIR AND EXHAUST SYSTEM FROM THE INTAKE FILTERS TO THE EXHAUST SILENCERS  
See Section II.C.1 through 7 and LO-TP-11103-002
3. DISCUSS THE IMPORTANCE OF MONITORING THE EDG COMBUSTION AIR AND EXHAUST SYSTEM  
See Sections II.D.4, II.E.2, and II.E.3
4. DESCRIBE THE RESPONSE OF THE EDG COMBUSTION AIR AND EXHAUST SYSTEM TO AN EDG TRIP SIGNAL  
See Section II.D.2

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**I PURPOSE STATEMENT**

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Following completion of this lesson, the student will possess those knowledges systematically identified for the performance of the DEA - COMBUSTION AIR AND EXHAUST tasks.

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**II LIST OF OBJECTIVES**

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1. Describe the operation of the EDG turbocharger.  
(KSA numbers: 064GEN0007)
2. Describe the basic flowpath of the EDG combustion air and exhaust system from the intake filters to the exhaust silencers.
3. Discuss the importance of monitoring the EDG combustion air and exhaust system.  
(KSA numbers: 064000A106)
4. Describe the response of the EDG combustion air and exhaust system to an EDG trip signal.

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