DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

April 5, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Ms. E. G. Adensam, Chief
Licensing Branch No. 4

Re: Catawba Nuclear Station
Docket Nos. 50-413 and 50-414

Dear Mr. Denton:

On March 21, 1984, representatives from Duke Power Company and the NRC Staff met at your offices in Bethesda, Maryland to discuss Duke's proposed program for resolution of the TDI diesel generator issue for Catawba. At the conclusion of this meeting, Duke committed to provide a written description of the Extended Operation Tests and the Inspection Plans for the 1A and 1B diesel generators. These descriptions are attached. Also attached is a description of the generic and site specific problems experienced at Catawba.

Very truly yours,

Hal B. Tucker/ROS

Hal B. Tucker

ROS/php

Attachment

cc: Mr. James P. O'Reilly, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

NRC Resident Inspector
Catawba Nuclear Station

Mr. Robert Guild, Esq.
Attorney-at-Law
P. O. Box 12097
Charleston, South Carolina 29412

A001
1/1

cc: Palmetto Alliance
2135½ Devine Street
Columbia, South Carolina 29205

Mr. Jesse L. Riley
Carolina Environmental Study Group
854 Henley Place
Charlotte, North Carolina 28207

Catawba Nuclear Station
Extended Operation Tests and Inspections
of
Diesel Generators

Table of Contents

1. Introduction

Concerns have been raised regarding the design and component integrity of diesel engines manufactured by Transamerica Delaval, Incorporated (TDI). Catawba Nuclear Station employs TDI diesels as safety-grade power supplies. Specifically, Catawba has two TDI diesels, Model DSRV-16-4, per unit. In this report the Catawba Unit 1 diesels will be identified as "1A" and "1B".

Duke Power Company has developed a program to verify the reliability of the TDI diesels installed at Catawba. The overall purpose of the program is to demonstrate that the Catawba TDI diesels can reliably perform their intended safety function, and that no technical reasons exist for not licensing Catawba Nuclear Station for power operations. Specifically, the program consists of three basic parts:

- o Participation in a TDI Owners Group Program that was formed to investigate the concerns and formulate corrective action plans to address these concerns.
- o Successful completion of regulatory requirements relating to the diesels.
- o Successful completion of an extended operation test and an extensive inspection program of the Catawba diesels.

In reviewing the operating history of similar Model DSRV-16-4 diesels it was noted that few of the nuclear service engines have significant operating hours. In addition, it was noted that some of the commercial engines with significant operating hours had operating loads and duty cycles significantly more severe and damaging than those expected for the Catawba diesels. Therefore, in order to expand the nuclear service data

base for Model DSRV-16-4 diesels Duke Power Company operated the 1A diesel generator at Catawba to accumulate over 810 hours of documented running time at loads well in excess of that needed for emergency power requirements.

The extended operation test was structured as an operational test run at loads equal to or greater than the required emergency power load to demonstrate the ability of the Catawba diesels to operate in a reliable fashion. The last operating period of the extended run test was a sustained run of over 7 days in duration. The disassembly and inspection of the 1A diesel following this extended operation test will confirm the adequacy of the engine parts' materials and critical dimensions or identify any deficient parts. The engines' ability to successfully start and pick up load has been extensively demonstrated during preoperational testing and there is no experience to date that suggests this ability is in question.

The extended operation test has also served to demonstrate the fatigue resistance of the Catawba diesel parts. The 810 hours of operation has subjected the major parts of the engine to greater than 10^7 stress cycles, and has served to demonstrate the fatigue life capability of the engine parts. A 4-cycle engine like the DSRV-16-4 is subject to a major stress cycle, compression and expansion, every 2 revolutions. The rated running speed for these engines is 450 RPM. Thus, to acquire 10^7 of these stress cycles, the engine had to run for approximately 740 hours; since about 810 operating hours have been accumulated, more than 10^7 cycles have been experienced. The ability to operate 10^7 stress cycles at the required load is generally accepted as a means to empirically demonstrate that mechanical parts made of carbon or low alloy steel have essentially indefinite fatigue

lifetime for the required load condition; thus, Catawba 1A diesel mechanical parts loaded by firing cycles can be considered as having proven acceptable fatigue lifetimes.

This report describes the diesel 1A extended operation test and its results, and describes the inspection plan to be used for the 1A diesel. The proposed extended operation test and inspection plan for the 1B diesel is also described.

2. Summary

The extended operation test demonstrated that the Catawba 1A diesel is capable of sustained operation at high loads. The extended operation test subjected the major parts of the engine to over ten million stress cycles to empirically demonstrate an adequate fatigue life for the engine parts. During the extended operation test the engine's operating parameters were closely monitored to detect any degradation in engine performance. No engine degradation was detected and the last test period involved continuous diesel engine operation for over 7 days.

An extensive inspection program is presently underway for the 1A diesel to verify the mechanical reliability of the Catawba engine. The scope of the inspection includes all engine parts that could cause failure of the diesel, degradation of diesel performance, or failure of a part that eventually would cause failure of the diesel. The inspection methods being employed include visual, nondestructive examination (liquid penetrant, magnetic particle, eddy current, ultrasonics, and radiography), dimensional, material properties (material comparison, verification and hardness), and other special methods (torsiograph, as-found bolt torque, reassembly bolt torque).

The inspection plan is based upon:

- Inspection of engine parts identified as one of the generic problems by the TDI Owners Group.
- Inspection of engine parts recommended by the TDI Owners Group.
- Inspection of engine parts relating to Catawba engine specific failures.

o Inspection of general engine parts to evaluate wear patterns.

The Catawba inspections are being performed in accordance with written Catawba procedures and are being controlled under the Duke Power Quality Assurance Program.

The Catawba 1B diesel will begin an extended operation test to expand its running time under high load conditions to at least 750 hours in the near future. Following completion of the extended operation test an inspection program will be initiated. The scope and extent of that inspection will be based upon the results of the 1A diesel inspection and inspections of other TDI emergency diesels.

Successful completion of the extended operation tests and the extensive inspections of the Catawba 1A and 1B diesels will demonstrate their capability to serve as safety grade equipment for the Catawba Station.

3. Extended Operation Test Program

3.1 Purpose

The purposes of the extended operation test program are to:

- Demonstrate that the Catawba 1A and 1B TDI Model DSRV-16-4 diesels are capable of sustained operation without major failures (e.g., failure of crankshaft, pistons, cylinder liner).
- Subject the major engine parts to over 10^7 stress cycles to empirically demonstrate the fatigue capability of those parts.
- Identify any beginning of life engine or break-in type failures that will occur with this type of diesel. These "break-in" failures typically occur early in life in all machinery, even well designed and constructed machinery.
- Expand the data base for DSRV-16-4 operation in emergency power service.
- Verify the suitability of modifications made to the Catawba diesel.

3.2 Extended Operation Test Description

The test run for diesel 1A extended its documented run time to over 810 hours. The controlling Catawba plant procedure for surveillance of the 1A diesel test was TP/1/B/1100/03, "Diesel Generator 1A Extended Run". The Catawba Nuclear Station procedures that control diesel operation are:

- OP/1/A/6350/02, "Diesel Generator Operation"
- OP/1/A/6550/02, "D/G Lube Oil"
- OP/1/A/6550/01, "Diesel Generator Fuel Oil System Operation"

The extended operation test planned for diesel 1B will extend its documented run time to at least 750 hours. Its controlling surveillance and operation procedures are the same as identified above for diesel 1A. The surveillance procedure used during the extended run provides for the following data collection:

- o Vibration data from thirty points around the engine base and near the turbochargers taken daily.
- o Lubricating oil samples taken daily from the Lube Oil Sump System before filtering. Daily tests to be made for percent water and viscosity.
- o Fuel samples taken from each tanker unloaded (approximately 2 to 3 tanker trailers every two days). Each sample is tested for water and sediment content, and specific gravity. Samples are drained from the day tank hourly to visually inspect for water.
- o Engine parameters such as load, exhaust temperatures, lube oil pressure, etc., monitored continuously and recorded hourly.
- o Problems encountered during engine operation are documented listing immediate action taken, proposed long term action, and to what extent the run was interrupted.

3.2.1 Vibration Analysis

Vibration data is taken at the following thirty points using either the Nicolet Spectrum Analysis System or the TEC Monitoring System, or both systems every day until the run is completed. Data is not taken unless the engine has been running a minimum of six continuous hours during a normal work day.

Point	Description
H01	Horz Generator Pedestal Bearing
V02	Vert Generator Pedestal Bearing
A03	Axial Generator Pedestal Bearing
H04	Horz Base LB at Cylinder-8L
H05	Horz Cam Cover Base at Cylinder-8L
H07	Horz Cam Cover Base Between Cylinders 4L & 5L
H08	Horz Base LB at Cylinder-1L
H09	Horz Cam Cover Base at Cylinder-1L
A10	Axial LB Cam Cover Housing (Engine Front)
A11	Axial RB Cover Housing (Engine Front)
A12	Axial Crankshaft Gear Housing (Engine Front)
T13	Turbocharger LB Horzontal on Turbo
T14	Turbocharger LB Vertical on Support Base
T15	Turbocharger Front Support Bar LB at Intercooler
T16	Turbocharger RB Horizontal on Turbo
T17	Turbocharger RB Vertical on Support Base
T18	Turbocharger Front Support Bar RB at Intercooler
H19	Horz Sub-Base RB at Cylinder-8R
H20	Horz Cam Cover Base RB at Cylinder-8R
H21	Horz Sub-Base RB Between Cylinders 4R & 5R
H22	Horz Cam Cover Base RB Between Cylinders 4R & 5R
H23	Horz Sub-Base RB at Cylinder-1R
H24	Horz Cam Cover Base at Cylinder-1R
V25	Vert Block RB at Cylinder-1R
V26	Vert Block RB Between Cylinders 4R & 5R
V27	Vert Block RB at Cylinder-8R
V28	Vert Block LB at Cylinder-8L
V29	Vert Block LB Between Cylinders 4L & 5L
V30	Vert Block LB at Cylinder-1L

Base line vibration data were established for both the Nicolet and TEC systems.

On a daily basis the TEC system is used to monitor all 30 points. This data is reviewed by a Maintenance Engineer trained in vibration analysis. If a significant change is detected in any of the parameters, then the Nicolet system is used to monitor the point in question to confirm the significant change. A comparison plot is then prepared between the Nicolet Baseline Data and the Nicolet Data to document the significant change.

The vibration monitoring test equipment consists of:

- o Nicolet System

  Nicolet Scientific Corporation Model 446A "Mini Ubiquitous" FFT Computing Spectrum Analyzer with a range of 1 Hz to 100,000 Hz.

- o TEC System

  TEC Monitor Model 1310 (EXP) Smart Meter System consisting of:

  - TEC Accelerometer Model 154 (S/N 113) with a range of 5 Hz to 10,000 Hz and a 100 Hz sensitivity of 103 millivolts/"g".
  - Comparison and plots are provided by the "INTELLI-TREND" software package written by TEC (January 1984) for an IBM Personal Computer.

- o Teac R-61 Digital Data Acquisition System using three (3) IRD 544 Velocity Pickup Probes with a range of 12 Hz to 1000 Hz and an output of 764 ± 10 millivolts RMS/per inch per second.

3.2.2 Lube Oil Samples

Lube oil samples are taken to show that the oil still has those properties necessary to provide proper lubrication. Daily samples are taken from the lube oil sump system at some point after the oil leaves the engine but before it is filtered. These samples are tested for percent water content and for viscosity per Catawba procedures CP/0/A/8100/23 and CP/0/A/8100/24 (Opaque Method), respectively. A log of the

results copied from the chemistry lab results log book is included in the surveillance procedure documentation package.

3.2.3 Fuel Oil Samples

Fuel oil samples are taken to show that the fuel meets industry and company standards for Number 2 Diesel Fuel Oil.

Because the main fuel oil storage tanks cannot be recirculated while the fuel oil system is lined up for engine runs and because of the inventory turnover required for this continuous run, the samples taken from the tanker for delivery acceptance will very closely represent the contents of the main storage tank and therefore provide a suitable means for monitoring fuel oil supply to the diesel.

Fuel oil samples are taken from each tanker to be unloaded. The samples are a composite of all compartments of the tanker. The fuel is tested on site for specific gravity and water and sediment per Catawba procedures CP/O/A/8100/10 and CP/O/A/8100/26, respectively. The test results are obtained and found satisfactory before the fuel oil is unloaded. A log of the results copied from the chemistry lab results log book is included in the surveillance procedure documentation package.

Fuel oil is drawn from the bottom of the day tank once during each hour the engine is running and is inspected for obvious water and sediment. If significant quantities are found, the Test Coordinator is notified for evaluation.

3.2.4 Engine Parameters

Engine operating parameters are monitored throughout the extended operation test. A number of engine operating temperatures are recorded on strip charts as part of normal diesel operation. Other parameters are recorded hourly.

The temperatures recorded on the strip chart are:

- Exhaust Temperature of each of the 16 Cylinders
- Jacket Water Temperature In and Out of the Engine
- Lube Oil Temperature In and Out of the Engine
- Intake Air Temperature In and Out of the Right Bank Aftercooler
- Intake Air Temperature In and Out of the Left Bank Aftercooler

The parameters recorded hourly are:

- Generator Volts
- Generator Amps
- Power Factor
- Generator Load
- Generator Stator Temp.
- Lube Oil Pressure
- Lube Oil Filter Differential Pressure
- Right Bank Turbocharger Lube Oil Pressure
- Left Bank Turbocharger Lube Oil Pressure
- Fuel Oil Pressure
- Fuel Oil Filter Differential Pressure
- Jacket Water Pressure
- Right Bank Intake Manifold Pressure
- Left Bank Intake Manifold Pressure
- Lube Oil Tank Level
- Exhaust Temperature of each of the 16 Cylinders (Same as recorded on strip chart)
- Right Bank Exhaust Temperature
- Left Bank Exhaust Temperature

The engine operating parameters are reviewed on a daily basis by the Operations Shift Supervisor and the Test Coordinator to identify any significant changes in operating parameter values. All significant changes are documented in problem reports.

3.2.5 Problems Encountered

Any problems encountered during operation are documented in Significant Problem Reports. As appropriate, a "Non-Conforming Item" (NCI) report may also be initiated for the problem as covered by the Duke Power Quality Assurance Program. The Significant Problem Report will contain, as appropriate, a description of the problem, the immediate action taken, proposed long term action, the extent the run was interrupted, and the NCI report number.

4. Results of Diesel 1A Extended Operation Test

The 1A diesel extended operation test was initiated on January 25, 1984, and was successfully completed on March 9, 1984. During that time period the engine operated about 613 hours of documented run time. That time added to the 197 hours of run time accumulated prior to the extended run test results in a total documented run time of about 810 hours for the 1A diesel. The following information summarizes the test run results.

4.1 Operating Profile

The Catawba TDI DSRV-16-4 diesels have a rated load of 7000kw. The maximum calculated emergency diesel generator load under blackout conditions is 5714kw (the engines have about an 18.4 % margin in load capability). During the extended operation test, the engine was operated at loads in excess of the required 5714kw approximately 97% of the test period. Specifically, during the last 390 hours of documented extended run test period the generator load was in excess of 5800kw 96% of the operating time. Figure 4-1 illustrates, for the last 390 hours, the diesel 1A operating profile with a bar chart that indicates the percent of diesel operating time the diesel generator load was in excess of the specified load. The diesel load was calculated based on generator volts, amps and power factor.

4.2 Vibration Analysis

The daily vibration plots were compared to the baseline plot to identify any abnormal or significant changes in vibration levels, any longer term trends in vibration levels, or any other anomalies. During the extended operation test period no abnormal or significant changes in vibration levels or trends were identified.

4.3 Lube Oil Analyses

The daily samples of lube oil were tested for viscosity and water content. All analyses showed acceptable values for lube oil water content and viscosity.

4.4 Fuel Oil Analyses

The samples of fuel oil from the delivery tankers were tested for specific gravity and percent of water and sediment. All analyses showed acceptable values for fuel oil specific gravity and percent of water and sediment.

The hourly samples of the fuel oil day tank typically showed no water was present. Any small amount of water present was drained by the operator.

4.5 Operating Parameters

The diesel operating parameters, both on the strip charts and log sheet, were reviewed each day to ascertain significant or abnormal changes and to look for trends in the data indicating gradual degradation of the engine. With the exception of two cases, no significant or abnormal changes or data trends were detected in the operating parameter reviews. The two cases of significant trends in data were:

- A slowly increasing jacket water discharge temperature was detected starting just past midnight on February 18, 1984. The jacket water temperature increased from a normal value of about 170°F to about 200°F. In addition, the temperature would sometimes jump from 200°F to 250°F rapidly. After an investigation, a defective

thermocouple was found and replaced. This resulted in the indicated jacket water temperature returning to a normal value of about 170°F.

- Over about a 20 hour period on February 27, 1984, the lube oil pressure to both the right bank and left bank turbochargers slowly decreased from a normal value of about 22 to 23 psig to about 18.5 to 19 psig. After an investigation, the lube oil pump inlet strainer was found to be plugging. Cleaning the strainer resulted in an immediate return to normal lube oil pressures. No damage to the turbochargers was sustained.

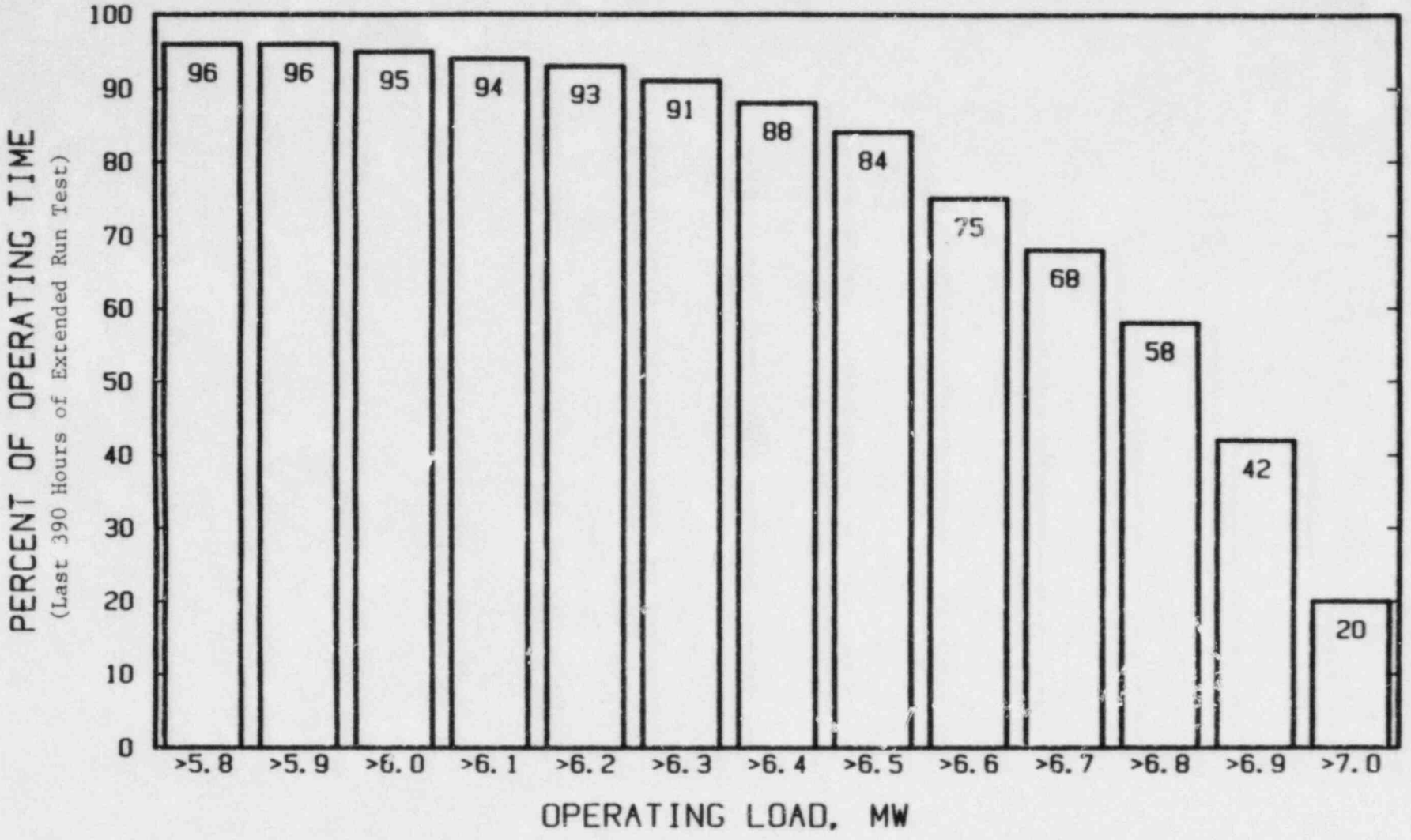
4.6 Problem Reports

Several problem reports were generated during the course of the extended run test. These reports covered the following engine parts:

- Pushrods
- Fuel line fitting
- Turbocharger thrust bearings
- Cylinder head
- Fuel injection pump valve holder
- Turbocharger prelube oil lines
- Turbocharger adapter (to the intercooler)
- Lube oil and jacket water thermocouples
- Crankcase cover capscrews
- Subcover (rockerarm) assembly
- Turbocharger lube oil drain line
- Turbocharger exhaust mainfold mounting bolts

Further discussion of these problems is given in section 7.

FIGURE 4-1



CATAWBA NUCLEAR STATION DIESEL GENERATOR 1A	PERCENT DIESEL OPERATING TIME VS. DIESEL GENERATOR LOAD

5. Inspection Plan for Catawba Diesel 1A

A comprehensive inspection plan has been developed for the Catawba Diesel 1A. The inspections follow the extended operation test of diesel 1A and were started on April 4, 1984.

5.1 Objective of Inspection Plan

The primary objective of the Catawba 1A diesel inspection plan is to verify the mechanical reliability of the specific parts and components of the Catawba 1A diesel following approximately 810 hours of diesel operation at high loads. This objective will be met by verifying the following:

- The parts are free from deleterious conditions, such as cracks, excessive wear, pitting, distortion, etc.
- The parts have critical dimensions in agreement with the original design (taking into account normal wear).
- The materials of construction are suitable for their intended use.

5.2 Bases for Inspection Plan

The Catawba 1A diesel inspection plan is based upon the following:

- Inspection of engine parts relating to the 16 generic TDI diesel problems identified to the Nuclear Regulatory Commission. These engine parts will be inspected to either verify that no similar problems exist with the Catawba DSRV-16-4 diesel, or identify and quantify the nature and extent of the the 1A diesel problems.
- Inspection of engine parts recommended by the TDI Diesel Owners Group. These recommended inspections cover the critical parts of the diesel, i.e., those parts whose failure could result in failure

or degradation of the diesel. The type and extent of inspection methods are based upon TDI diesel operating and failure experience.

- o Inspection of engine parts relating to the Catawba engine specific failures and problems based on past Catawba operating experience. In some cases they involve engine parts that are not considered critical (i.e., Class C as defined in section 5.3).
- o Inspection of engine parts based on engineering judgement and evaluation of wear patterns.

5.3 Scope of Inspection Plan

The 1A diesel inspection plan will include all of the critical components and parts of the diesel and associated systems that were supplied by TDI to Catawba. The TDI Owners Group has classified engine components according to the following:

Class	Importance of Component Failure
A	Failure can result in shut down of the diesel.
B	Failure can result in reduced capacity of the diesel or result in eventual failure in a Class A component
C	Failure does not significantly impact the ability of the diesel to meet its load requirements

The Catawba 1A diesel inspection plan includes all Class A and Class B components. In some cases Class C components are also included in the inspection plan.

Table 5-1 identifies all the parts in the Catawba DSRV-16-4 diesel, the part's classification, and extent of inspection. The extent of inspection of each part is dependent upon the part's importance to operation and to its failure history in Catawba's and other TDI diesels.

5.4 Inspection Methods

A variety of inspection methods will be employed to examine the Catawba DSRV-16-4 diesel parts. Each inspection method is selected based upon:

- The probable failure mode of the part and the probability of the inspection method to detect it.
- The attribute being determined.
- Results of previous inspections.

The specific inspection methods to be employed include the following:

Visual - Examine for:

- Wear and wear patterns
- Surface distress
- Cracks
- Freedom of motion
- Corrosion/erosion
- Foreign material
- Proper fitup
- Gasket leaks
- Proper lubrication
- As-built verification of system piping configuration and support

Dimensional Measurements - Examine for:

- Absolute value of critical dimensions
- Clearances
- Comparative values of identical parts
- Verification that proper parts are used
- Proper fitup of mating parts

Nondestructive Examinations

- Liquid penetrant and magnetic particle - Examine for:
  - Cracks and discontinuities
  - Material distress
  - Material integrity

- Eddy current - Examine for:
  - Cracks and discontinuities not inspectable by liquid penetrant or magnetic particle because of physical configuration or surface condition
- Ultrasonics - Examine for:
  - Wall thickness of parts
  - Depth of cracks (as appropriate)
  - Volumetric examination of material integrity
- Radiography - Examine for:
  - Volumetric examination of material integrity

Material Properties - Examine for:

- Comparison of engine materials to materials of known composition and properties by use of a material comparitor
- Verification that proper non-metallic materials are being used for gaskets, seals and couplings by visual methods and documentation review
- Material hardness

Special Inspections

- Torsiograph
- As-found torque values for bolted or screwed connections
- Proper torque values are used during reassembly of bolted, screwed or compression connections

5.5 Inspection Test Plan

A summary of the inspection test plan for the Catawba 1A diesel is given in Table 5-1. Each engine part or component to be inspected is listed together with the part number, part classification and the sample size to be inspected for each inspection method being employed. All Class A and B bolted or screwed connections will have their as-found and reassembly torque values verified and documented, hence this is not listed separately in Table 5-1. Also not listed in Table 5-1 is the general visual inspection of all parts during disassembly and reassembly of the diesel.

The Duke Power Company, Nuclear Production Department Administrative Policy Manual will be used to control all work done on-site at Catawba Nuclear Station. Specific Catawba Station procedures have been developed for all disassembly, inspection, testing and reassembly operations and are listed below. The Duke Power Quality Assurance Program will be used to control and audit all phases of the diesel inspection program.

Disassembly and Reassembly

MP/O/A/1000/01	Cylinder Head and Associated Parts
MP/O/A/1000/02	Pistons, Rods and Cylinder Liners
MP/O/A/1000/03	Main Crankshaft Bearing
MP/O/A/7400/01	Fuel Pump
MP/O/A/7400/40	Turbocharger

Inspection

MP/O/A/1000/04	Cylinder Heads and Associated Parts
MP/O/A/1000/05	Pistons, Rods, Bushings and Shells
MP/O/A/1000/06	Crankshaft, Main Bearings and Turning Gear
MP/O/A/1000/07	Idler Gears and Pump Drive Gears
MP/O/A/1000/08	Gear Case Gasket and Bolting
MP/O/A/1000/09	Fuel Pump and Fuel Pump Linkage
MP/O/A/1000/10	Lube Oil System, Piping and Sump
MP/O/A/1000/11	Cylinder Block, Liner and Jacket Water
MP/O/A/1000/12	Starting Air Distributor
MP/O/A/1000/13	Jacket Water Pump
MP/O/A/1000/14	Camshaft and Gear
MP/O/A/1000/15	Intake and Exhaust Manifold
MP/O/A/1000/16	Governor and Overspeed Trip
MP/O/A/1000/17	Flywheel and Bolting
MP/O/A/1000/18	Turbocharger and Intercooler

5.6 Inspection Team

The inspection team will consist of primarily Duke Power Company (DPC) personnel supplemented by others as necessary. DPC craftsmen will perform the actual engine disassembly and reassembly. DPC technicians and engineering staff personnel will perform the inspections and provide the administrative support for the inspection program. Other members of the inspection program team include:

- Failure Analysis Associates - Eddy current testing and torsiograph installation and testing.
- Stone and Webster - Provide interface between DPC and Owners Group and materials comparison testing.
- Dominion Engineering, Inc. - Provide on-site assistance in the inspection effort and prepare final summary inspection report.
- Gustafson Associates - Provide on-site assitance in the inspection effort.

Table 5-1. Catawba Diesel 1A Inspection Plan Matrix

Part Name	Class	Part No.	Sample Size, Percent of Engine Parts Inspected						
			Dimen.	Visual	Surface NDE	Vol. NDE	Material	Hardness	Notes
Lube Oil Pressure Regulating Valve	A	00-420	To be developed (Note 8)						
Main Bearing Cap Base Assembly	A	02-305A	-	30	-	-	-	-	-
Main Bearing Studs and Nuts	A	02-305C	10	30	-	-	-	-	-
Main Bearing Caps	A	02-305D	-	30	30	-	-	-	-
Lube Oil Internal Headers	A	02-307A	-	100	-	-	-	-	-
Lube Oil Tubing and Fittings-Internal	A	02-307B	-	100	-	-	-	-	-
Lube Oil Line Supports-Internal	B	02-307D	-	100	-	-	-	-	-
Crankshaft and Turning Gear	A	02-310A	100	100	38	-	-	-	3,4
Crankshaft Bearing Shell	A	02-310B	30	30	-	-	-	-	-
Crankshaft Thrust Bearing Ring	A	02-310C	100	-	-	-	-	-	4
Crankcase Assembly	A	02-311A	-	100	-	-	-	-	-
Crankcase Seal	B	02-311B	To be developed						
Crankcase Mounting Hardware	B	02-311C	To be developed						
Cylinder Block	A	02-315A	25	-	100	-	-	-	-
Cam Bearing Caps and Dowels	B	02-315B	To be developed						
Cylinder Liner	A	02-315C	100	100	-	-	20	20	-
Cylinder Block Jacket Water Manifold	B	02-315D	-	100	-	-	-	-	-
Cylinder Block Studs	B	02-315E	-	31	-	-	3	-	-
Cyl Block Jacket Wtr Manifold Nuts	B	02-315F	-	100	-	-	-	-	-
Cylinder Block Seals and Gaskets	B	02-315G	To be developed						
Jacket Water Inlet Manifold Assembly	B	02-316A	To be developed						
Jacket Water Inlet Manifold Coupling	B	02-316B	To be developed						
Jacket Water Inlet Manifold Vent Line	B	02-316C	To be developed						
Jacket Water Discharge Manifold	B	02-317A	To be developed						
Jacket Water Disc, Man. Coupling	B	02-317B	To be developed						
Jacket Water Disc. Man. Supports	B	02-317C	To be developed						
Flywheel	A	02-330A	To be developed						
Flywheel Bolting	A	02-330B	-	100	-	-	-	-	-
Front Gear Case Bolting	C	02-335B	-	100	-	-	-	-	-
Connecting Rods and Bushings	A	02-340A	100	100	100	-	25	25	-
Connecting Rod Bearing Shells	A	02-340B	100	100	100	100	-	-	-
Piston	A	02-341A	100	100	25	-	-	-	5
Piston Rings	A	02-341B	25	100	-	-	25	-	-

Table 5-1. Catawba Diesel 1A Inspection Plan Matrix

Part Name	Class	Part No.	Sample Size, Percent of Engine Parts Inspected						
			Dimen.	Visual	Surface NDE	Vol. NDE	Material	Hardness	Notes
Piston Pin Assembly	A	02-341C	25	25	-	-	25	25	-
Intake Tappets	A	02-345A	-	25	-	-	-	-	-
Fuel Tappets	A	02-345B	-	25	-	-	-	-	-
Fuel Pump Base Assembly	B	02-345C	To be developed						
Camshaft Assembly	A	02-350A	-	100	-	-	-	-	-
Camshaft Bearing	B	02-350B	-	-	-	-	-	-	7
Camshaft Supports, Bolting and Gear	A	02-350C	-	100	-	-	100	100	-
Idler Gear Assembly (Crank to Pump)	A	02-355A	-	100	-	-	-	-	-
Idler Gear Assembly	A	02-355B	-	100	-	-	-	100	-
Air Start Valve	A	02-359	100	100	-	-	-	-	-
Cylinder Head	B	02-360A	100	100	100	100	-	-	2
Intake and Exhaust Valves	B	02-360B	25	100	-	-	25	-	-
Cylinder Head Bolting	B	02-360C	To be developed						
Cylinder Head Gaskets	B	02-360C	-	100	-	-	-	-	-
Valve Springs	B	02-360D	-	100	-	-	-	-	1
Subcover Assembly	B	02-362A	-	100	100	-	-	-	-
Fuel Injection Pump	B	02-365A	-	-	-	100	-	100	-
Fuel Injection Tips	B	02-365B	To be developed						
Fuel Injection Tubing	B	02-365C	To be developed						
Fuel Injection Tubing Supports	B	02-365D	To be developed						
Fuel Pump Linkage and Control Shaft	A	02-371A	-	-	-	-	100	100	-
Fuel Pump, Linkage, Bearings and Shaft	A	02-371B	-	100	-	-	-	-	-
Intake Manifolds	B	02-375	100	100	-	-	-	-	-
Exhaust Manifold	B	02-380A	To be developed						
Exhaust Manifold Bolting	B	02-380B	9	9	-	-	-	-	-
Cylinder Block Cover, Gaskets & Bolts	C	02-385B	To be developed						
Crankcase Cover Assembly	C	02-386A	-	100	-	-	-	-	-
Crankcase Cover Gaskets & Hardware	C	02-386B	To be developed						
Intake & Intermediate Rocker Arm Assy	B	02-390A	100	100	100	-	100	100	-
Exhaust Rocker Arm Assembly	B	02-390B	100	100	100	-	100	100	-
Intake & Exhaust Pushrods	B	02-390C	-	100	100	-	-	-	-
Connector Pushrod	B	02-390D	-	100	100	-	-	-	-
Rocker Arm Bushings	B	02-390E	-	100	-	-	-	-	-
Rocker Arm Bolting	B	02-390G	-	100	25	-	-	-	-
Overspeed Trip Governor	A	02-410A	-	100	-	-	-	-	-

Table 5-1. Catawba Diesel 1A Inspection Plan Matrix

Part Name	Class	Part No.	Sample Size, Percent of Engine Parts Inspected						
			Dimen.	Visual	Surface NDE	Vol. NDE	Material	Hardness	Notes
Gov Overspeed Trip & Accessory Drive	A	02-410B	-	100	100	-	100	100	-
Overspeed Trip Couplings	A	02-410C	-	100	-	-	100	-	-
Overspeed Trip Vent Valves	A	02-410D	To be developed						
Governor & Tach Drive Gear & Shaft	A	02-411A	-	100	100	-	100	100	-
Governor Drive Couplings	A	02-411B	-	100	-	-	100	-	-
Governor Linkage	A	02-413	-	100	-	-	-	-	-
Speed Regulating Governor	A	02-415A	-	100	-	-	-	-	-
Governor Booster Servomotor	B	02-415B	To be developed						
Governor Heat Exchanger Assembly	A	02-415C	-	100	-	-	-	-	-
Lube Oil Pump	A	02-420	To be developed						
Jacket Water Pump	A	02-425A	-	100	-	-	100	100	-
Jacket Water Pipe and Fittings	B	02-435A	To be developed						
Jacket Water Pipe Supports	B	02-435B	To be developed						
Intercooler Piping Assembly	B	02-436A	To be developed						
Intercooler Piping-Coupling, Bolt, Gskt	A	02-436B	To be developed						
Turbo Cooling Water Pipe & Fittings	B	02-437A	To be developed						
Turbo Cooling Water Pipe Supports	A	02-437B	To be developed						
Start Air Manifold Pipe, Tubing & Ftg	A	02-441A	To be developed						
Start Air Manifold Vlvs, Strners, Fltrs	A	02-441B	To be developed						
Start Air Manifold Pipe Supports	A	02-441C	To be developed						
Starting Air Distributor Assembly	A	02-442A	100	100	-	-	-	100	6
Start Air Dstrbtor Tubing,Ftg, Gskts	A	02-442B	To be developed						
Fuel Oil Booster Pump	A	02-445	To be developed						
Fuel Oil Piping and Tubing	A	02-450B	To be developed						
Fuel Oil Filters and Strainers	B	02-450C	To be developed						
Fuel Oil Piping Supports	A	02-450D	To be developed						
Fuel Oil Filters	B	02-455A	To be developed						
Fuel Oil Strainers	B	02-455B	To be developed						
Fuel Oil Filter Mounting Hardware	A	02-455C	To be developed						
External Lube Oil Lines	A	02-465A	-	100	-	-	-	-	-
External Lube Oil Line Supports	A	02-465B	-	100	-	-	-	-	-
Turbocharger Lube Oil Piping	B	02-467A	-	100	-	-	-	-	-
Turbocharger Lube Oil Piping Supports	B	02-467B	-	100	-	-	-	-	-
Turbocharger Bracket	B	02-475A	-	100	-	-	-	-	-

Table 5-1. Catawba Diesel 1A Inspection Plan Matrix

Part Name	Class	Part No.	Sample Size, Percent of Engine Parts Inspected						
			Dimen.	Visual	Surface NDE	Vol. NDE	Material	Hardness	Notes
Turbocharger Air Butterfly Valve	A	02-475B	-	100	-	-	100	100	-
Turbocharger Air Intake Piping	B	02-475C	To be developed						
Turbocharger Bracket Bolting	B	02-475D	-	8	-	-	8	-	-
Control Panel Cabinet	A	02-500A	To be developed						
Control Panel Annunciators	B	02-500B	To be developed						
Control Air Accumulator	A	02-500F	To be developed						
Control Air System Valves	A	02-500G	To be developed						
Control Air System Pressure Switches	B	02-500H	To be developed						
Control System Relays	A	02-500J	To be developed						
Control System Solenoid Valves	A	02-500K	To be developed						
Control Air System Piping, Tubing, Ftngs	B	02-500M	To be developed						
Control Panel Wiring	A	02-500N	To be developed						
Lube Oil Sump Tank	B	02-540A	-	100	-	-	-	-	-
Lube Oil Sump Tank Ftngs, Pipe, Valves	B	02-540B	-	100	-	-	-	-	-
Lube Oil Sump Tank Mounting Hardware	B	02-540C	-	100	-	-	-	-	-
Foundation Bolts and Anchors	B	02-550	To be developed						
Instrumentation Thermocouples	B	02-630D	To be developed						
Engine & Aux Module Wiring Conduit	A	02-688A	To be developed						
Engine and Aux Module Wiring	A	02-688B	To be developed						
Engine and Aux Module Wiring Boxes	A	02-688C	To be developed						
Engine Alarm Sensors	A	02-690	To be developed						
Engine Shutdown Tubing and Fittings	B	02-695A	To be developed						
Engine Shutdown Valves, Regs, & Orific	A	02-695B	To be developed						
Engine Shutdown Trip Switches	A	02-695C	To be developed						
Jacket Water Standpipe, Ftngs, Gasket	B	00-700A	To be developed						
Jacket Water Standpipe Valves	B	00-700B	To be developed						
Jacket Water Standpipe Supports	B	00-700C	To be developed						
Jacket Water Standpipe Switches	B	00-700E	To be developed						
Jacket Water Standpipe Bolting Materials	B	00-700F	To be developed						
Fuel Oil Duplex Strainer	A	02-825D	To be developed						
Intercooler	B	F-068	-	100	100	-	-	-	-
Turbocharger	A	MP-022/3	100	100	-	-	-	-	-

Notes to Table 5-1

1. Intake and exhaust valve springs have proper color code.

2. Ultrasonic wall thickness measurement of fire deck area and fuel nozzle area.

3. A torsiograph will be developed of the crankshaft.

4. Crankshaft web deflections and thrust clearance will be measured with the diesel both hot and cold.

5. Measure torque on belleville spring loaded bolts.

6. Hardness of the spools will be measured only if excessive wear is measured on one or more of the spools.

7. If inspection of camshaft lobes show no abnormal wear, then no inspections of the camshaft bearings will be performed.

8. All inspections noted as "To be developed" will involve visual inspections or functional tests

6. Inspection Plan for Catawba Diesel 1B

A specific inspection plan for Catawba diesel 1B has not yet been developed. As previously identified an extended operation test is underway for diesel 1B to extend its high load operating time to 750 hours. Prior to the extended operation test the following inspections were performed on two engine cylinders:

- Liquid penetrant examination of cylinder block top surface around the cylinder and between the head studs and cylinder liner.
- Ultrasonic wall thickness measurements of cylinder head.

The following inspections were performed on all 16 cylinders:

- Visual inspection of subcover assembly.
- Visual inspection of all intake, exhaust and connector pushrods.
- Visual inspection of all rocker arm assemblies.
- Visual inspection of all intake and exhaust valve springs.

Following the extended operation test additional inspections will be performed. The extent of those inspections will be based upon the results of the inspections on the Catawba 1A diesel and other TDI emergency diesels. An appropriate sampling plan will be developed at that time.

7. Catawba Generic and Specific Problems

This section of the report lists the generic problems that have and have not occurred at Catawba along with other specific problems. Attachment 1 lists the "Generic problems not experienced at Catawba." Attachment 2 lists the "Generic problems experienced at Catawba" along with the specific diesels that experienced the problem, and the number of occurrences per diesel. Attachment 3 lists the "Catawba Specific Problems", the specific diesels that experienced the problem, and the number of occurrences per diesel. The problems listed do not include enhancements to the diesels resulting from 10CFR Part 21 reports, such as piston skirt enhancements.

The remaining portion of this section reviews each Catawba problem in more detail, and addresses the "cause", "consequences" and "corrective action" for each.

7.1 TDI Generic Problems Experienced at Catawba

Pushrods

A number of pushrods have been observed to have cracks on diesel 1A. Similar cracks are expected to occur on diesel 1B pushrods. The pushrods originally furnished had ball to tube welding defects. The cracked pushrods operated in 1A and 1B with no adverse affects to either engine's operation. The 1A pushrods have been replaced with an improved design that uses a friction weld between the spherical part and the tube. Diesel 1B is scheduled to have its pushrods replaced by April 1984.

Fuel Line Fitting

A fuel line fitting on the 1A diesel leaked due to a dented ferrule on the inside of the compression nut which secures the fuel line to the injector. The dented ferrule resulted from an unknown impact. During an emergency condition, this leaky fitting would not have adversely affected the engine's operation. The injection line and fitting were replaced. No further failures of this type have been experienced.

Turbocharger Thrust Bearings

The turbocharger thrust bearings have experienced excessive wear on diesels 1A and 1B. This wear is believed to be due to a lack of prelube oil during multiple fast starts of the diesels. The excessive wear of the turbocharger bearings did not adversely affect the diesels' operation during the extended run test. The bearings were replaced and the prelube oil flow rate was increased to prevent excessive wear on the replacement bearings.

A recent 10CFR21 has been issued by TDI addressing this situation, and as a result, Catawba expects to have the improved prelube oil system installed by June 1984.

Cylinder Heads

One cylinder head on diesel 1A developed a minor jacket water leak (approximately 4 gals/24 hours) within the injector bore and above the injector seat. One cylinder head on diesel 1B also developed minor jacket water leak similar to the leak on 1A. The causes of both cylinder head leaks are under investigation. Both diesels operated several days with the leaks and with no adverse affects to the engine's operation. The 1A cylinder head has been replaced, and the 1B cylinder head will be

replaced prior to the start of the diesel 1B extended run test.

7.2 Catawba Specific Problems

Fuel Injection Pump

One fuel injection pump nozzle valve holder cracked as a result of a material defect. This was confirmed by a metallurgical analysis. In an emergency condition, the injector pump failure would not have adversely affected the engine's operation. The failed fuel injection pump was replaced. All pump nozzle valve holders at Catawba will be inspected to verify that material defects do not exist in the other pump nozzle valve holders.

Turbocharger Prelube Oil Lines

Two turbocharger prelube oil line fatigue failures occurred at the ferrule of a compression fitting during the 1A extended run test. Both failures are considered to be due to improper installation (i.e., over-tightening) of the tubing compression nut and excessive vibration. During an emergency condition this situation would not have adversely affected the engine's operation. The prelube oil lines have been replaced using an approved nut tightening procedure and additional clamps. Vibration dampening devices were installed on the tubing to decrease the vibration amplitude. As previously noted, the improved prelube oil system will be installed by June 1984.

Turbocharger Adapter

A turbocharger to intercooler adapter cracked at the flange weld. This was evaluated to be due to a misalignment between the two components. This situation had no adverse affects on the engine's operation. The adapter was replaced. In the future, Catawba will take extra care to

ensure proper flange alignment prior to torquing any turbocharger flange bolts.

Lube Oil and Jacket Water Thermocouples

Incorrect temperature indications were noted on the lube oil and jacket water systems during the extended run test. These were found to be due to thermocouple lead failures (i.e., an intermittant short). This situation did not adversely affect the engine's operation. The engine was shut down at the operator's discretion to resolve the problem and replace thermocouples.

Crankcase Cover Capscrews

A 1/2 inch capscrew head was found to be missing from the 1A diesel crankcase access cover. During replacement of the capscrew, a second capscrew sheared off with less than 15 ft-lb of applied torque. This situation is under investigation, and is suspected to be due to an improper installation (i.e., over torque) of the capscrews prior to the extended run test. This situation did not adversely affect the engine's operation. The failed capscrews were replaced. Once the cause is confirmed, all affected capscrews will be replaced.

Subcover (Rockerbox) Assembly

One subcover assembly was observed to be damaged while replacing the diesel 1A pushrods. The damage is felt to have resulted from work performed during the reinstallation of the heat treated piston skirts, in 1983. At that time, it is suspected that the subcover assembly was installed with a misaligned rocker shaft dowel pin which caused the observed damages. This situation did not adversely affect the engine's operation during the extended run test. The subcover assembly was

replaced. In the future, Catawba will ensure proper dowel pin alignment prior to torquing bolts.

Turbocharger Lube Oil Drain Line

A temporary turbocharger lube oil drain line leaked on diesel 1A. This temporary modification was made because the original drain line furnished by TDI did not completely seal at the couplings. The temporary drain line fatigued and failed prior to completion of the extended run test. This situation would not have adversely affect the engine's operation in an emergency condition. The drain line was replaced. In addition, an improved permanent design will be installed by May 1984.

Turbocharger Exhaust Manifold Mounting Bolts

Four 1/2 inch stainless steel turbocharger exhaust manifold mounting bolts were found broken. The cause of this failure is under investigation. The bolt failures did not adversely affect the engine's operation. The failed bolts have been replaced. When the cause of failure is determined, appropriate action will be taken to prevent reoccurrence of the failure.

Exhaust Valve Tappet (Rocker Arm Adjusting Screw Swivel Pad)

One exhaust valve tappet cracked on diesel 1B. The failure is presently under investigation (the failure appears to be due to improper seating of the internal ball and socket of the tappet). This situation had no adverse affects to the engine's operation. The failed tappet was replaced.

ATTACHMENT 1

GENERIC PROBLEMS NOT EXPERIENCED AT CATAWBA

- Crankshaft
- Connecting Rod Bearings
- Pistons
- Cylinder Liners
- Cylinder Block
- Enginer Base
- Head Studs
- Rocker Arm Capscrews
- Connecting Rods
- Electrical Cables
- Fuel Injection Lines
- Jacket Water pumps
- Air Start Valve Capscrews

ATTACHMENT 2

GENERIC PROBLEMS EXPERIENCED AT CATAWBA

	DG1A	DG1B
o Push Rods	x	x
o Fuel Line Fittings	x(1)	
o Turbocharger Bearings	x(2)	x(2)
o Cylinder Heads	x(1)	x(1)

Note: Number of occurrences are noted in parenthesis.

ATTACHMENT 3

CATAWBA SPECIFIC PROBLEMS

	DG1A	DG1B
o Fuel Injection Pump	x(1)	
o Turbocharger Pre Lube Oil Lines	x(2)	
o Turbocharger Adapter	x(1)	
o Lube Oil and Jacket Water Thermocouples	x(6)	
o Side Cover Capscrews	x(2)	
o Rocker Box Subassembly	x(1)	
o Turbocharger Lube Oil Drain Line	x(1)	
o Turbocharger Exhaust Manifold Mounting Bolts	x(4)	
o Exhaust Valve Tappet		x(1)

Note: Number of occurrences are noted in parenthesis.