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**THIRD INTERIM REPORT  
ON STATUS OF  
GAS TURBINE TRANSIT BUS  
DEMONSTRATION PROGRAM**

**PRESENTED TO:**

**U.S. DEPARTMENT OF ENERGY  
5th INTERNATIONAL SYMPOSIUM ON  
AUTOMOTIVE PROPULSION SYSTEMS  
DEARBORN, MICHIGAN**

**APRIL 15, 1980**

**PREPARED BY**

**BOOZ, ALLEN & HAMILTON Inc.  
TRANSPORTATION CONSULTING DIVISION**



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THIRD INTERIM REPORT ON STATUS OF  
GAS TURBINE TRANSIT BUS DEMONSTRATION PROGRAM

THE TRANSPORTATION CONSULTING DIVISION OF BOOZ, ALLEN & HAMILTON IS PLEASED TO PRESENT THIS THIRD INTERIM REPORT ON THE STATUS OF THE GAS TURBINE TRANSIT BUS DEMONSTRATION PROGRAM.

THE OBJECTIVE OF THE PROGRAM IS TO ACCELERATE ACCEPTANCE AND COMMERCIALIZATION OF GAS TURBINE ENGINE TECHNOLOGY BY CONDUCTING A COMPREHENSIVE DEMONSTRATION PROJECT THAT PROVIDES OPERATIONAL EXPERIENCE AND DATA TO THE TRANSPORTATION INDUSTRY.

THIS PROGRAM IS UNDER THE JOINT SPONSORSHIP OF THE DEPARTMENTS OF ENERGY AND TRANSPORTATION AND HAS BEEN PLANNED IN 3 PHASES TO DEMONSTRATE PROGRESSING ENGINE IMPROVEMENTS AS TRANSIT COACH GAS TURBINE ENGINES MOVE TOWARD COMMERCIALIZATION. EACH PHASE CONSISTS OF BUS/ENGINE INTEGRATION, PROVING GROUNDS TESTS, AND REVENUE SERVICE DEMONSTRATION.

WE ARE PRESENTLY WORKING IN PHASE I OF THE PROGRAM. IN THIS PHASE, FIVE PROTOTYPE GAS TURBINE ENGINES, MODEL GT-40404, MANUFACTURED BY THE DETROIT DIESEL ALLISON DIVISION OF GENERAL MOTORS CORPORATION, ARE BEING INTEGRATED INTO FIVE RTS-II MODEL TRANSIT COACHES, MANUFACTURED BY GENERAL MOTORS CORPORATION AND SUPPLIED BY THE MASS TRANSIT ADMINISTRATION (MTA) OF BALTIMORE, MARYLAND. THEY WILL ALL BE ACCEPTANCE TESTED AT THE TRANSPORTATION RESEARCH CENTER PROVING GROUNDS IN OHIO, WHERE ONE GAS TURBINE COACH WILL ALSO BE PERFORMANCE AND MILEAGE TESTED AGAINST A DIESEL RTS-II COACH. THEN THE FIVE TURBINE COACHES WILL BE DEMONSTRATED IN REVENUE SERVICE ON THE STREETS OF BALTIMORE FOR ONE YEAR. THEY WILL OPERATE OUT OF THE BUSH STREET DIVISION—BE DRIVEN BY MTA DRIVERS AND REPAIRED AND SERVICED BY MTA MECHANICS.

THE FIRST DIESEL-TO-TURBINE ENGINE CONVERSION IS DONE. MTA COACH #3319, WHICH COMPLETED THE CONVERSION PROCESS JUST A FEW WEEKS AGO AT OUR CONVERSION FACILITY, MODERN ENGINEERING SERVICE IN TROY, MICHIGAN, IS BEING EXHIBITED AT THE SYMPOSIUM TODAY. FOLLOWING THIS EXHIBITION, IT WILL BEGIN TESTING ACTIVITIES AT THE PROVING GROUNDS.

THE ENGINE IN THIS FIRST COACH IS ALL-METAL. THE DECISION TO INCORPORATE CERAMIC REGENERATORS INTO THE PHASE I DEMONSTRATION COACHES WAS MADE TOO LATE FOR CERAMICS TO BE INCORPORATED AS ORIGINAL EQUIPMENT, BUT THEY WILL BE RETROFITTED INTO THIS ENGINE FOLLOWING THE SHAKEDOWN TESTS. THE OTHER GAS TURBINE ENGINES WILL BE EQUIPPED WITH CERAMIC REGENERATORS BEFORE INSTALLATION IN THE COACHES. ALTHOUGH CERAMIC COMPONENTS WILL HAVE A NEGLIGIBLE EFFECT ON PERFORMANCE TESTS, THEY SHOULD SUBSTANTIALLY IMPROVE REGENERATOR LIFE DURING THE MILEAGE TESTS AND THE DEMONSTRATION

AN AUXILIARY OIL-FIRED HOT WATER HEATER IS BEING ADDED TO THE COACHES IN PHASE I AS A TEMPORARY DESIGN APPROACH TO PASSENGER COMPARTMENT HEAT AND AIR CONDITIONING. THIS WAS NECESSARY BECAUSE OF THE REMOVAL OF THE COOLING RADIATOR, WHICH IS NOT NEEDED FOR THE TURBINE ENGINES. A MORE EFFICIENT HEATER DESIGN ARRANGEMENT WILL BE DEVELOPED IN PHASE II AFTER FURTHER EXPERIENCE IS GAINED FROM OPERATION OF THE GAS TURBINE COACHES.

SOME PERFORMANCE TRIALS HAVE BEEN CONDUCTED ON THIS GAS TURBINE COACH. THESE WERE DONE IN ORDER TO IDENTIFY AND RESOLVE A NUMBER OF PROBLEMS PRIOR TO ACTUAL TESTING FOR ACCEPTANCE AND DELIVERY.

ONE OF THE PROBLEMS IDENTIFIED WAS ENGINE-GENERATED NOISE FROM THE AIR INTAKE AND THE EXHAUST. THE NOISE LEVEL WAS REDUCED BY:

- LINING THE AIR INTAKE DUCT AND PLENUM WITH SOUND-ABSORBING FOAM
- SANDWICHING HIGH TEMPERATURE FIBERGLASS SOUND-ABSORBING MAT BETWEEN A DOUBLE EXHAUST WALL CONSTRUCTED OF STAINLESS STEEL
- SEALING THE ENGINE ACCESS DOOR WITH RUBBER GASKETS
- COVERING THE MAIN ENGINE DOOR WITH SOUND-ABSORBING FIBERGLASS MAT.

THESE CORRECTIONS REDUCED THE SAE PASS-BY NOISE MEASUREMENTS TO 75-76 dB(A), ABOUT 10dB BELOW THE CORRESPONDING DIESEL FIGURES.

OTHER PROBLEMS ON THE TURBINE COACH WERE STANDING START ACCELERATION, WHICH IS IMPORTANT IN MAINTAINING BUS SCHEDULES, AND TOP SPEED, WHICH IS IMPORTANT ON EXPRESSWAY ROUTES. ACCELERATION WAS IMPROVED TO WITHIN ONE QUARTER SECOND OF THE TIMES FOR A DIESEL AND TOP SPEED WAS IMPROVED TO APPROXIMATELY 65 MPH, WHICH IS COMPARABLE TO A DIESEL-POWERED COACH.

IMPROVEMENTS RESULTING FROM THE PERFORMANCE TRIALS HAVE DONE MUCH TO ENSURE A SOUND AND RELIABLE INSTALLATION AND TO INCREASE THE POTENTIAL FOR A SUCCESSFUL DEMONSTRATION PROGRAM.

THE DECISION TO DEMONSTRATE THE ENGINE'S ABILITY TO OPERATE ON NON-PETROLEUM FUEL DURING THE LAST PART OF THE PHASE I DEMONSTRATION HAS ALSO REQUIRED SOME MODIFICATIONS. FOR INSTANCE, THE FUEL CARRYING CAPACITY OF THE COACHES HAD TO BE INCREASED TO MEET THE SAME DAILY OPERATING RANGES AND THE

TANK MATERIALS AND DELIVERING SYSTEM HAD TO BE COMPATIBLE WITH THE FUEL SELECTED. THE 125-GALLON METAL FUEL TANK WAS REPLACED WITH TWO 125-GALLON NYLON TANKS SO THAT THE ENGINES COULD OPERATE ON ETHANOL, THE NON-PETROLEUM FUEL SELECTED FOR PHASE I. ALTHOUGH ETHANOL MAY NOT BE THE TRANSIT FUEL OF THE FUTURE, IT CAN BE PRODUCED FROM RENEWABLE RESOURCES, SUCH AS CORN, AND IS READILY AVAILABLE FROM EXISTING DISTILLERIES. ITS USE WILL ALLOW AN ALTERNATE DEMONSTRATION AT THIS TIME AND WILL PROVIDE THE MEANS OF IDENTIFYING POTENTIAL OPERATIONAL PROBLEMS WITH THE DISTRIBUTION AND HANDLING OF NON-PETROLEUM FUELS.

THE SECOND CONVERSION IS ALMOST COMPLETED, CONVERSION OF THE THIRD AND FOURTH COACHES HAS BEGUN, AND IN MAY THE FIFTH COACH WILL BE SHIPPED TO MODERN FOR CONVERSION.

TESTING AT THE PROVING GROUNDS ON THE ONE TURBINE TEST COACH (#3319) AND THE DIESEL RTS-II TEST COACH WILL BEGIN THE FIRST OF MAY AND WILL LAST APPROXIMATELY SEVEN MONTHS. THE COACHES WILL BE PERFORMANCE AND MILEAGE TESTED AS COMPLETE SYSTEMS, RATHER THAN COMPONENT BY COMPONENT. THE OBJECTIVE IS TO DETERMINE COMPLIANCE WITH THE PERFORMANCE REQUIREMENTS FOR ADVANCED DESIGN TRANSIT COACHES AND TO IDENTIFY ANY MILEAGE-RELATED FAILURES. DATA FROM THE DIESEL COACH WILL FORM THE BASELINE FOR COMPARISON OF THE TWO POWER PLANTS.

MTA'S DEMONSTRATION PLAN FOR THE FIVE GAS TURBINE COACHES HAS BEEN FINALIZED AND THE DEMONSTRATION SHOULD BEGIN THIS SUMMER. THE PLAN DETAILS MTA'S APPROACH TO MANAGING THE ONE-YEAR DEMONSTRATION AND TO EVALUATING THE POTENTIAL FOR GAS TURBINE ENGINES IN URBAN TRANSIT BUSES. MANAGEMENT ACTIVITIES ARE PLANNED TO INCLUDE DAILY OPERATING PROCEDURES FOR THE VEHICLES, SELECTION AND TRAINING OF DRIVERS AND MECHANICS, STORAGE OF THE COACHES AND RELATED SPARE PARTS, AND PROCEDURES FOR THE



CONDUCT OF THE PUBLIC AWARENESS EFFORTS. EVALUATION ACTIVITIES ARE PLANNED TO INVOLVE COLLECTING DATA ON PHYSICAL MEASUREMENTS, COST ACCOUNTING, AND SUBJECTIVE RESPONSES. THESE DATA WOULD FORM THE BASE FOR COMPARISON OF THE GAS TURBINE ENGINE WITH THE DIESEL ENGINE.

GOALS WE EXPECT TO ACCOMPLISH IN THE NEXT REPORTING PERIOD ARE:

- COMPLETE THE CONVERSION OF THE REMAINING THREE MTA COACHES TO GAS TURBINE POWER
- COMPLETE ACCEPTANCE TESTING OF ALL GAS TURBINE POWERED COACHES
- COMPLETE PERFORMANCE TESTING OF THE GAS TURBINE COACH AND THE DIESEL COACH
- COMPLETE SYSTEMS TESTING OF THE GAS TURBINE COACH AND THE DIESEL COACH
- BEGIN ANALYSIS OF PROVING GROUNDS TESTS RESULTS
- PLACE METAL REGENERATORS IN GAS TURBINE ENGINE OF THE FIRST COACH WITH CERAMIC REGENERATORS
- BEGIN THE DEMONSTRATION OF ALL FIVE GAS TURBINE COACHES IN BALTIMORE.

THE FOLLOWING PAGES SHOW:

- PROGRAM PARTICIPANTS
- PHASE I SCHEDULE
- GT-404-4 ENGINE

- COACH #3319 AT MODERN ENGINEERING
- COACH #3319 AT HYATT REGENCY
- GAS TURBINE COACH PAINT SCHEME.

## PROGRAM PARTICIPANTS

U.S. DEPARTMENT OF ENERGY, OFFICE OF TRANSPORTATION PROGRAMS

- OVERALL PROGRAM MANAGEMENT

U.S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION

- DEMONSTRATION MANAGEMENT

NASA-LEWIS RESEARCH CENTER

- SYSTEMS MANAGEMENT

BOOZ · ALLEN & HAMILTON INC., TRANSPORTATION CONSULTING DIVISION

- OPERATIONS MANAGEMENT

DETROIT DIESEL ALLISON DIVISION, GENERAL MOTORS CORPORATION

- ENGINE MANUFACTURER

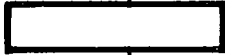

MASS TRANSIT ADMINISTRATION, BALTIMORE, MARYLAND

- DEMONSTRATION SITE

AMERICAN PUBLIC TRANSIT ASSOCIATION

- ADVISORY GROUP

# PHASE I SCHEDULE

ACTIVITIES	1979	1980	1981	1982
Integration				
Testing				
Demonstration		