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Urban Mass Transportation Administration

Air Starters for Transit Buses

Prepared by:
Transportation Systems Center

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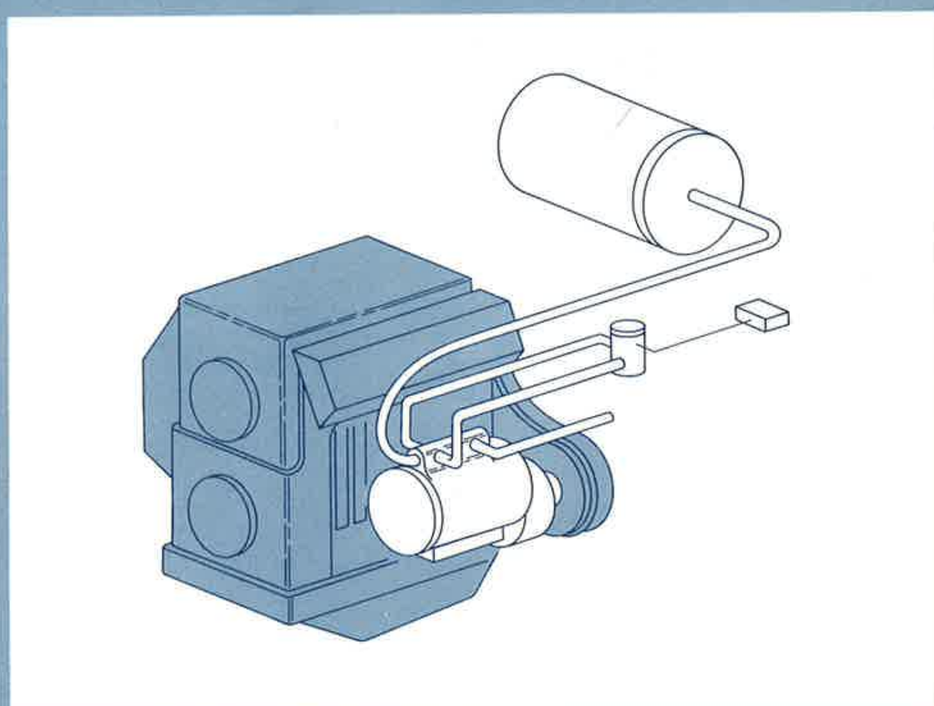

Technical Assistance - an UMTA Program

U.S. Department of Transportation

Urban Mass Transportation Administration

Air Starters for Transit Buses

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PREFACE

This study was conducted to familiarize transit agencies with the potential benefits gained by utilizing air starting systems as an alternative to electrical starting systems. The potential benefits include improved starting reliability under hot and cold weather conditions and cost savings in electrical system maintenance.

Special thanks are extended to: Mr. T. M. Foley, District Sales Manager of Ingersoll-Rand Company and Mr. George Kohlweiler, Regional Manager of StartMaster, who have provided the technical background and information on air starters. Mr. Corneilus J. Harrington from the U. S. Department of Transportation, Transportation Systems Center, who acted as an advisor and arranged many of the transit agency visits.

We also want to thank all the transit agencies who, with much patience, have contributed both time and information to bring this report to completion.

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AIR STARTERS FOR TRANSIT BUSES

INTRODUCTION

Many transit agencies around the country experience bus operating problems due to their electrical starting system, whether the cause is cold weather, hot engine conditions, or degraded battery performance. Continuous problems with a starting system can result in high maintenance costs. As a relatively recent alternative to electric starters in the bus industry, air starters are showing up at transit agencies that have had serious starting problems in the past. Air starters, as the name implies, uses compressed air as its main power source. Therefore, problems such as battery drainage, reduced alternator life and electrical fires may be minimized. This study was conducted to familiarize transit bus agencies with the potential benefits available through the utilization of air starters. Major potential benefits include improved starting reliability under hot engine and cold weather conditions and cost savings in electrical system maintenance.

BACKGROUND

History

Developed in the early 30's, air starters have progressed from starting stationary engines in marine applications to the trucking industry and finally to the bus transit industry. At the time the air starter was introduced to diesel powered highway vehicles, the system was inefficient for the type of service demanded. Failures such as air leaks occurred, causing "no starts" which brought about temporary discontinuation by the truck manufacturers. At that time, off-highway construction vehicles also had stringent engine starting requirements. Having access to an ample air supply at the construction sites, air starting flourished in this market. As a result of some modifications (detailed in the following section) the air starting system has become a reliable starting device for on-highway vehicles as well. Many diesel powered trucks are again operating on air starting systems. Air starters were introduced to the bus transit industry by the Toronto Transit Commission (TTC) which piloted a test program on six retrofits from 1974 through 1977. Findings observed at that time were better reliability, reduced maintenance requirements and fewer safety hazards.

Potential Benefits

A key concern of transit officials is the reliable starting of buses under both hot and cold weather conditions. Internal engine expansion which results from heat build-up within the engine increases the torque required to start the engine. Air starters can provide more torque and speed to the engine than electric starters. On the other hand, since the energy of the compressor air is not appreciably affected by temperature, cold weather does not hinder the air starter's capability to provide full power for turning over an engine.

Cost savings in electrical system maintenance is another major benefit. Battery life is improved, since it is no longer subjected to deep cycle-type discharging associated with electrical starter cranking. Alternator life is extended because it is no longer subjected to the heavy load required to charge drained batteries. It is also possible that fewer and lighter duty batteries and alternators can be used to meet the needs of lighting and electrical accessories. In terms of starter maintenance, an air starter is not vulnerable to problems associated with electrical starters such as prolonged cranking, burned-out armatures and damaged brushes. When maintenance is required, it should be an easier system to trouble-shoot and repair. Finally, with the elimination of high amperage wiring and connections used with electrical starters, starter safety problems are reduced.

Today's Status

Presently, air starting systems are installed on 40% of all diesel powered trucks. As a result of air starters being successfully tested on buses by the Toronto Transit Commission, transit agencies in cities such as Toronto, Montreal, Pennsylvania and St. Louis, have standardized on air starters. Approximately 4,087 air starter units are operating on buses at

33 different transit agencies. These units have been produced by two air starter manufacturers, namely the Ingersoll-Rand Company and StartMaster, a division of the Sycon Corporation.

DESCRIPTION

The major components of an air starting system include the starter itself (which consists of a rotor, a gear reduction assembly and a Bendix drive gear), air tank, relay and check valves, lubricator (which in most cases is fed from the fuel return line), starter control valve, pipings and a muffler (See Figure 1 & 2). Basically, compressed air flows from the air tank to the rotor, producing a torque which is increased in magnitude by the reduction assembly and transmitted to the Bendix gear which, when engaged with the engine flywheel, proceeds to turn the engine over. The air tank is then replenished by the compressor while the engine is running.

There are two types of air starters; inertia and pre-engaged. The inertia type allows a gradual flow of compressed air to the starter so as to provide a gentle engagement of the drive gear with the engine flywheel. Difficulites have arisen with this arrangement. Due to cold weather, dirt and/or lack of lubrication, the Bendix gear often sticks in place, causing a significantly large amount of pressurized air to build up behind it and virtually forcing the gear into the flywheel, whether or not the teeth are lined up. The pre-engaged type has two air lines running from the air tank to the starter. An air starter control valve is attached to one of the lines and when opened, allows a small burst of air to flow directly behind the Bendix gear, engaging it with the flywheel ring gear. Responding to the movement of the Bendix gear, a relay valve in the main line from the tank to the starter opens, permitting full air pressure to the rotor.

The air starter design has gone through many changes and improvements since its introduction in 1948. Besides those horsepower, torque and speed changes which have been made to keep up with engine growth, some of the major modifications made to the Ingersoll-Rand starter have been:

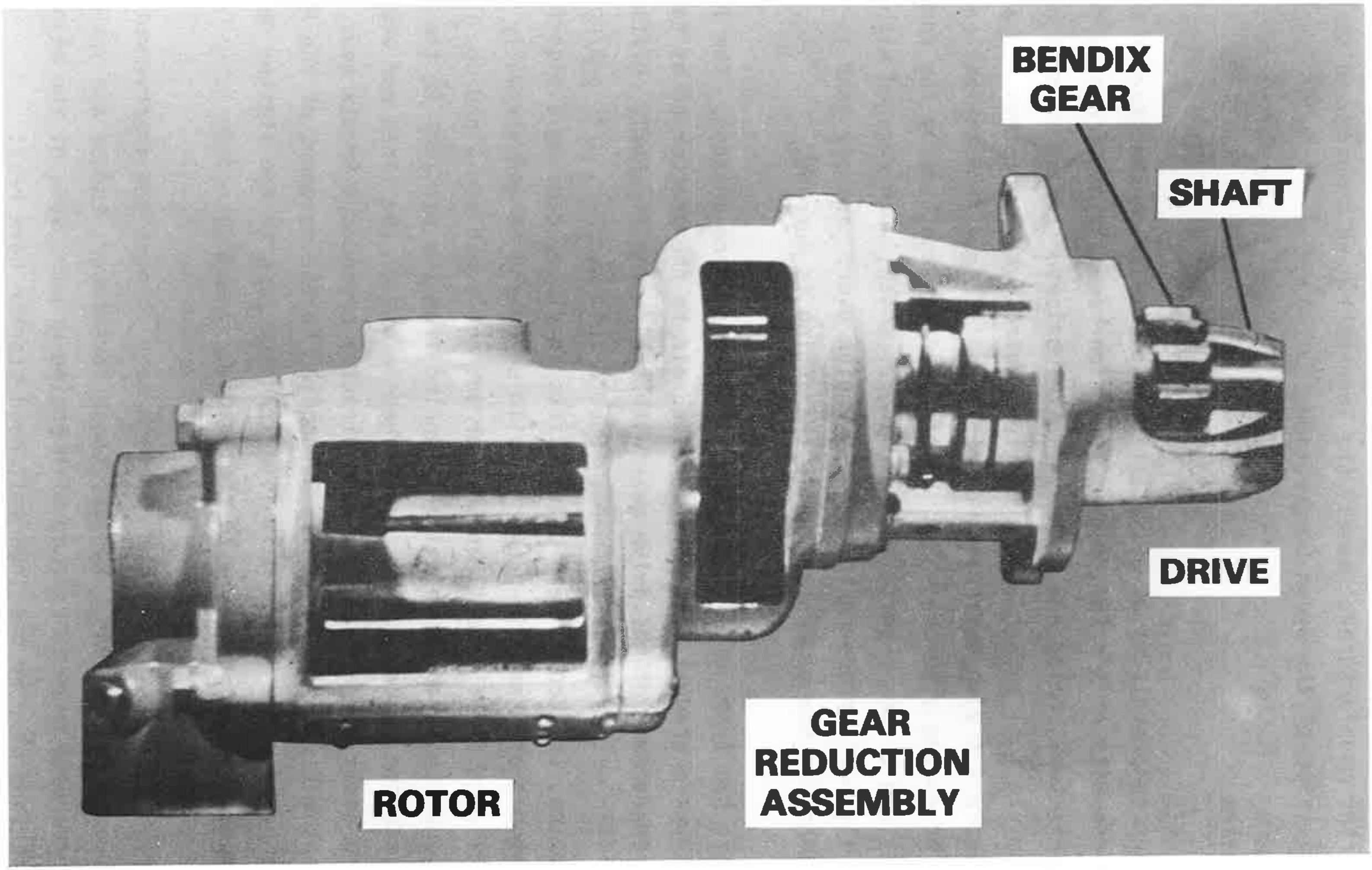

FIGURE 1. AIR STARTER

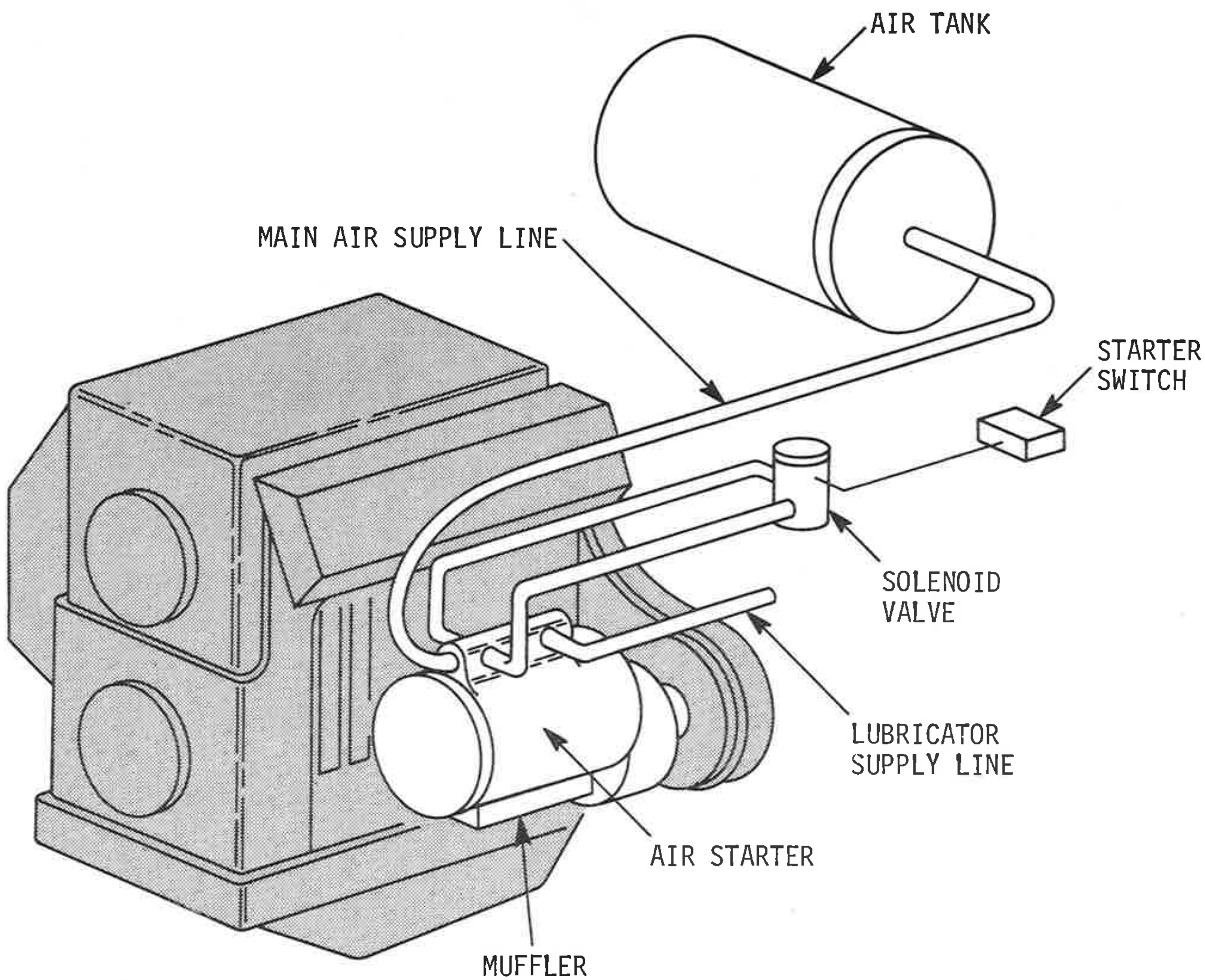

FIGURE 2. AIR STARTING SYSTEM ATTACHED TO A BUS ENGINE

1) A pre-engaged starter was developed and introduced in 1961 and directed toward reducing the shock load and potential gear teeth/pinion damage encountered with inertia engagement.

2) Automatic lubrication was introduced in 1971 for each start cycle to insure proper motor operation without freezing and to prevent rotor vanes from "sticking" due to moisture, dirt or wear. It also includes a self-priming system that does not require a gravity feed.

3) Starter motors were completely redesigned to reduce their weight and to provide a more uniform starting torque; these were introduced in 1976.

4) Better performing and more durable relay valves were used beginning in 1979 through the introduction of stainless steel springs and aluminum diecast housings.

5) Viton O-rings and seals were introduced in 1982 for transit bus applications to ensure a leak-free system.

StartMaster entered the market in 1971 with an integral lubricator, relay valve and muffler. A positive blade displacement system was also developed which has an eccentric cam that pre-positions the rotor blades directly in the air stream to prevent freeze-up and a "blow-by" condition.

APPROACH

The approach used in conducting this study was to contact, primarily by telephone, those transit agencies operating air starters, question each as to the number of air starters in operation, type, specific reasons for testing and using the air starter and to contribute any experiences related to the air starters' overall performance. The study was basically a qualitative evaluation with very little data being available on reliability and cost. The 17 agencies contacted are shown below; air starters at these agencies have been operating on a variety of transit buses such as Advanced Design Bus (ADB) & New Look. In addition, meetings were held with both manufacturers, Ingersoll-Rand and StartMaster.

Bi-State - St. Louis
Cambria County Transit Authority (CCTA) - Johnstown, PA
Chicago Transit Authority (CTA) - Chicago
Erie Metro - Erie
Greater Cleveland Rapid Transit Authority (GCRTA) - Cleveland
Grand Rapids Transit Authority (GRTA) - Grand Rapids
Kansas City Area Transit Authority (KCAT) - Kansas
METRO - Seattle
Massachusetts Bay Transit Authority (MBTA) - Boston
Metropolitan Transit Authority (MTA) - New York
Metropolitan Transit Authority (MTA) - Wichita
Salt Lake City
Southeastern Michigan Transit Authority (SEMTA) - Detroit
Southeastern Pennsylvania Transit Authority (SEPTA) - Philadelphia
SUNTRAN - Albequerque, New Mexico
Toronto Transit Commission (TTC) - Toronto
Washington Metropolitan Area Transit Authority (WMATA) - Washington, DC

The number of air starters that are currently operating on buses at the above agencies amount to 1506, with 434 at TTC, 404 at Bi-State, 256 at SEPTA, 231 at METRO with the rest spread over the remaining agencies. An additional 304 are on order by TTC, Erie, Metro, MTA of Wichita and CCTA, with 246 of those being ordered by TTC.

FINDINGS

- Due to pollution control regulations and/or transit district directives in many cities, the bus driver is often required to shut his engine off during layover time between trips. Due to heat build-up within the engine, the engine temperature rises significantly, causing engine internal parts to expand. As this expansion occurs, clearances between parts decrease and the torque required to start the engine increases. An air starter can respond faster in this situation than an electric starter because of its capacity to produce higher torque. Bi-State confirmed this feature and claimed they have not experienced any "hot-start" road failures with air starters. TTC, SEMTA and MTA of Wichita also have observed improved "hot stall" starting.

- When temperatures fall below freezing, problems arise with a battery's ability to maintain its full charge capacity. This causes available cranking power to decrease while the required cranking power to start the bus increases. With an air starter, the availability of compressed air to generate power under such conditions is not affected. SEPTA, Bi-State, TTC, Erie, Metro, MTA of Wichita and SUNTRAN all have observed improved and faster cold weather starting.

- Though all agencies generally reported improved starting experience, a few indicated some problems with the air system regarding leakage and capacity for consecutive starts. Both the MBTA and SUNTRAN indicated that the number of starting attempts is limited to 2 or 3 on any given occasion by the capacity of the compressed air tank; thus, if a successful engine start is not obtained after 2 or 3 attempts, an auxiliary air supply is required. The air supply can either be carried by a service truck or from a bus equipped with an air starting system. Air leakage has been a problem at some agencies, particularly when long layovers (such as weekends) occur.

- Though equipped with mufflers, air starters do make more noise than electric starters when operating. Depending on the location of the bus at the time (inside storage, en-route, outside storage), the start-up event can be disruptive to the surrounding environment, particularly when the mufflers are worn. The MBTA confirmed this aspect of air starting systems.

- Another feature of an air starting system is the relative ease of trouble shooting. Finding a loose or poor conductive connection in an electrical starting system, for example, is more difficult than finding an air leak. By realizing the simplicity of an air starter over an electrical starter and its related circuitry, Bi-State's concern in having to train mechanics for maintenance and repair of "new hardware" was diminished.

- Air starters should reduce safety hazards. If an operator continues to crank an electric starter, this could create a hazardous low voltage/high current condition, resulting in a fire. Other hazards associated with an electric starter are loose or frayed cables or improper connection of jumper cables. SEPTA and Salt Lake City cited safer operation with their air starters, with SEPTA stating specifically a reduction in electrical fires.

- A key advantage of air starting systems over electric systems is the potential capability to reduce associated maintenance costs. Savings can be realized through reduced maintenance of the starter itself, associated equipment and also through a reduction in road-calls. Since the air starter is relatively easy to trouble shoot and repair, maintenance labor can be reduced. Both SEPTA and the MBTA indicated reduced maintenance time with their air starters. GCRTA, CTA, and WMATA were among several agencies that indicated prolonged battery life with use of air starters. Both SUNTRAN and CTA also were investigating the elimination of one battery on their coaches with use of an air starting system. Several agencies (MTA of Wichita, SEMTA, WMATA, etc.) observed a reduction in road calls associated with starting problems. TTC, SEPTA and MTA of New York stated that reduced maintenance costs were a prime consideration in their use and evaluation of air starters.

- Though reduced maintenance costs seem to be a viable claim of many agencies using air starters, the purchase price of an air starting system can be as much as double that of an electrical system. After an extensive effort to assemble maintenance and failure records, it was found that inadequate information exists at the agencies contacted to determine if air starting systems are more cost-effective on a life cycle basis than electrical systems. However, two agencies contacted (TTC and SEPTA) did claim a payback with air starters from 1 to 5 years.

CONCLUSIONS

Based upon this preliminary qualitative study, it appears that air starters offer advantages over conventional electric starters, particularly in the area of starting reliability. For those agencies experiencing starting problems under hot and/or cold conditions, the air starter seems to represent a viable alternative to a conventional system. However, not enough data has been collected at different locations to convincingly state that air starters offer a more cost-effective solution. More time for other transit agencies to collect specific data and complete their testing will be necessary in order to make a final evaluation.

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