Toronto Transit Locomotive Overview
Reference drawing EP 1442

Arva Industries Is pleased to offer this proposal for a sophisticated, multi-mode locomotive to the Toronto Transit Commission (TTC) in response to their Request for Proposal.

General

The locomotive is of a dual cab configuration with the various power plant components, compressed air, air brake system, etc. mounted above and below deck between the two cabs. Each cab is capable of operating the locomotive although neither cab can control the locomotive if the opposite cab is controlling.

Locomotive Frame

Arva Industries proposes to utilize one of its standard 55 foot long by 123 ½ inch wide, previously supplied work cars, modified for locomotive use for this RT-12 application. The 55 foot length will allow adequate space length to properly locate electrical equipment with related panels for maintenance, as well as provide end to end length for drive motors, drive line and trucks for track clearances and configuration.
The configuration will also allow ample spare room for locating the Wabco air system components proposed.

Stress Analysis

It is requested that Finite Element Analysis (FEA) Solid Works Cosmos be approved by the TTC engineer for structural analysis of frame, couplers, anti-climber, collision posts and truck connections.
The FEA will be performed in house by Arva Engineers and consultants.

Power Source

The locomotive is capable of operating with the primary power taken from three sources: diesel-electric, third rail D.C. power and optional battery power. Each of these modes is independent of the other and the mode of operation is selected by an operator’s switch in each of the cabs. The modes are not blended with one and another and are completely independent in operation. All systems share a common 600 VDC (nominal) traction and auxiliary power bus and this bus is connected to the various power sources via power contactors.

Propulsion

The traction portion of the locomotive involves two LeTourneau model B40 switched-reluctance (SR) traction motors and drives. These motors derive their mechanical energy from an iron-laminated armature rotated by electro-magnetic pulses generated from coils located in the stator. An IGBT drive system sequences the coil pulses in accordance with torque and speed commands to generate the mechanical energy output of the motor. The motors are forced air ventilated, using cooling air drawn across the IGBT heat sinks being ducted to the traction motors. The motors are designed as traction motors and are used in LeTourneau's line of diesel-electric mine loaders. A more detailed description of the LeTourneau switched – reluctance system is described in the appendix of this proposal.

Drive Line

Each traction motor is connected via drive shafts to the TTC supplied axle gearboxes located on the inner axle of each truck. The outer axle is then driven from a second drive shaft coupled to a drive output of the inner axle gearbox. Each traction motor drives one truck, and each truck has both axles driven, giving the vehicle a total of four-axle drive.

Auxiliary Power

Two types of auxiliary power supply are offered in this proposal.
This proposal includes the supply of an I Power TTC style H-6 Inverter which is capable of supplying:
A) Low voltage power
B) Battery bank charging should the optional battery traction system option be selected
C) Power for the 60 cfm air compressor
The inverter proposal is presently used on TTC revenue cars; therefore, no additional spare parts inventory would be required.
As noted in the base price of the locomotive, although the inverter system is more expensive than the LeTourneau Switch Reluctance powered alternator alternative – the long term maintenance expense would be less due to less components and no rotating components. A basic specification of the I Power Inverter is attached in the Appendix of this proposal.
Should TTC require the 250 cfm air compressor then the LeTourneau Inc. motor generator system would be required to power all auxiliary power needs. The system is sized sufficient to power the auxiliary loads including the 250 cfm air compressor.
The auxiliary power is taken off the common 600 VDC bus so as to simplify the circuits regardless of the source of the power (i.e. Diesel-driven alternator, third rail or optional battery power). Power would be converted via a 100 kW LeTourneau SR motor coupled to a Marathon-Electric 480 VAC, 3-phase alternator. This arrangement makes use of the precise torque control of the SR motor, provides a clean sinusoid for the 480 VAC components (versus the noise problems associated with DC-AC inverters), and which is less costly than a static inverter. Weight and size envelopes for the motor-alternator set are similar to a static inverter of equivalent power.
The 480 VAC auxiliary power bus provides power for the 250 cfm air compressor, the alternator and traction motor/IGBT blowers, the two HVAC refrigerant compressors, the 500 VDC traction battery charger and the 24 VDC low voltage power supply. The air compressor offered is an Ingersoll Rand XP75 compressor with air volume control. The model chosen has the variable volume control which has a higher efficiency over the capacity range of other air compressors, allowing for modulation of the compressor's output volume rather than the throttled air intake openings found in constant speed drives.

Engine Power

The diesel-electric system consists of a Detroit Diesel series 60 engine, certified for EPA Tier III off-highway operation and rated at 630 HP, which is the highest horsepower rating available in the 60 series engine. The engine is coupled to a LeTourneau #4B, single bearing traction alternator for traction power. The alternator output is rectified to a DC voltage and supplied to the main traction and auxiliary power bus through the 1250 amp alternator contactor. Specifications on the Detroit Diesel are described in the Appendix.

Third Rail Power

The traction and auxiliary power bus can also be powered by the TTC 600 VDC (nominal) third rail power source. Power is brought into the vehicle from four third rail shoe assemblies. The power goes through a main disconnect and a main fuse before entering the bus at the 1250 amp third rail contactor. Power returns back to the running rails via the second pole of the 1250 amp third rail contactor and the four ground brush assemblies located one on each axle. The ground rail brush assemblies are supplied by Ferraz-Shawmut which are custom machined for the application.

Battery Power Option

When in the battery mode, the traction and auxiliary power bus is powered by a lead-acid battery pack consisting of 192 cells in series for a nominal 500 VDC. The battery power is connected to the bus through a 150 amp, 750 VDC contactor. The batteries have capacity sufficient to power an 80-ton train for ten one-minute moves at 2 mph without recharging. The batteries quoted as standard are 40 ten year life supporting 40 amps for 75 minutes. A premium 20 year life battery supporting 80 amps for 45 minutes is also offered. See optional page for cost of premium life battery.

Controls

The main control functions on the locomotive are handled by the LeTourneau ICAM system. This system is a modular, digital system specifically designed for control applications in rugged, moving vehicle applications. The system is comprised of a master controller module, remote input/output modules, a translator module (for communication with the engine controller and other processors on the vehicle), and the traction system drive modules. The master controller module has provision for archiving fault conditions and also drives the two optional train operator's displays located in each cab.

Air and Brake System

Arva has contacted Wabco Locomotive Products to provide the legal brake system schematic and components required for this RT-12 locomotive.
Schematic drawings and design notes are attached for your review.
The air compressor offered as standard is an Ingersoll Rand 60 cfm model UP6-15-150.
The upgrade air compressor offered as optional is an Ingersoll Rand 250 cfm model XP75. Specifications for both units are attached in the appendix.
The air system incorporates the WABCO twin tower desiccant dryer and air reservoirs sized to handle the braking requirements of the locomotive
The handbrake operating mechanism will be an Ellcone-National Model 840.
All braking performance requirements will be in full compliance with the specification.

Wheel Slip / Slide System

Wheel slip is controlled by the LeTourneau ICAM system and is inherently incorporated into the SR traction motor control. As the drive system monitors rotation motor armature and controls motor torque and speed, wheel slip conditions are sensed and corrected with adjustments to the IGBT current pulsing and the sequencing of the pulses around the motor stator poles.
The Knorr wheel slide system is offered as optional. The system can be incorporated into the pneumatic brake system using axle mounted speed probes and a processor to vent brake cylinder air in the event of a sliding wheel condition.

Operator's Cab

The operator's cab will be manufactured in full compliance with the specification as required. It is proposed that a reputable supplier of cabs to TTC manufacture the cabs for the RT-12 locomotive.

HVAC Unit

The heating, ventilation and air conditioning unit will be supplied by Mine Air Systems. General information on Mine Air Systems is attached, along with some proposal drawings, the HVAC system would be specifically designed for TTC's tunnel/outdoor environment and temperatures.

Engine Cooling Exhaust and Intake

Arva has contacted Copper Core / Glacier Ontario to provide cooling for the Detroit 60 series 14 liter Tier III non-highway engine. The basic design of the radiator with charge air cooler is attached along with engine specification for your review.
Information regarding the Lubrizol Engine Control Systems muffler purifier is also enclosed for your review. The model AZ33M055 is recommended for use on the 14 liter 60 series Detroit engine.
The engine air cleaner selected for the atmospheric conditions is a Donaldson two-stage with a Donaspin Pre-Cleaner, as recommended by Donaldson and Detroit Diesel.

Fire Suppression System

The fire suppression system offered is manufactured by Ansul with Checkfire SC-N Detection and Actuation for Diesel Electric Locomotive.
The system will be a two (2) agent tank eight (8) nozzle model LTA101-30 with both cab and ground level manual actuators. It will also include a control module in each cab with linear detector wire, two Infrared Fire Detectors medium pressure hydraulic hose meeting SAE 100R1 single wire braid minimum specifications and a pressure switch for engine shutdown. The dry chemical fire system is temperature rated for -65 degrees F to +210 degrees F.
The fire suppression system is based on the following:

5 - Nozzles to protect engine and traction alternator
2 - Nozzles to protect traction motors
1 - Nozzle to protect optional battery bank
Linear detector wire to detect fire at engine area, traction motors and optional battery bank.

Emergency Recovery System

The emergency recovery dolly proposed will be modular in design, consisting of four (4) two wheel carts and four (4) perpendicular members which will allow for misc. rail clearance requirements. Each cart wheel will be mounted on double tapered Timken bearings.

As part of the dolly kit and to lift the end of the locomotive two (2) 31,000 lb capacity hydraulic cylinders and an air over hydraulic 10,000 psi pump will be supplied.

The air power source for powering the pump would be locomotive air. Air outlets would be provided at each end of locomotive.

Dolly design will permit assembly by two (2) men. A location will be provided for storage of the kit on the locomotive.

Systems Conclusion

Arva Industries Inc. in partnership with Diesel Power and Controls and LeTourneau Inc., believes this locomotive offers an excellent product for the Toronto Transit Commission. Although the locomotive is relatively complex with the specification requirements and the three possible sources of propulsion and auxiliary power, none of the major systems are unproven. The primary technical challenge is the combination of the components into a reliable, functional machine. The Arva team is certain this challenge can be accomplished. The team has extensive experience in frame and sheet metal fabrications, locomotive and transit systems, systems integration, and diesel and electric traction propulsion systems. With this expertise the individual members of the team are confident in the success of this project.

Attached is an overview profile of various company components for your review.