Keeping Melbourne Moving

Melbourne is the second most populous city in Australia and has a rail network of superlatives. Sulzer’s service center in Melbourne currently maintains a fleet of more than 2500 traction motors and motor/alternator sets. But Sulzer’s offering goes even beyond electrical repairs and upgrades of rotating machines. When Melbourne needed new impedance bonds for an improvement of its rail network infrastructure, the Sulzer team took up the challenge.
Melbourne's population is set to increase from the current 4.25 million to 7.7 million people by the year 2050. As such, the Victorian State Government is investing in expanding its light and heavy rail networks as well as other infrastructure. These investments will ensure that the city will continue to be able to move the growing population in and around the Melbourne C.B.D. (central business district) and its ever more sprawling outer suburbs.

The Melbourne metro rail network has 16 interlinked electrified lines with more than 370 km of track. This network currently runs 20 hours a day, 365 days of the year. In 2013–14, the network saw more than 230 million passenger trips.

Sulzer's service center in Melbourne exclusively manages the whole fleet of DC traction motors and motor/alternator sets as well as a large segment of the newer AC traction motors for the metro rail network. To do this, the service center has developed a team with experts who are available 24/7/365.

Increasing service on metros and trams
The city of Melbourne also boasts one of the world's oldest and largest tram networks. It has electric trams that have been in service since 1906, and it uses over 250 km of track. Sulzer's beginnings into the Victorian traction repair business started within the older direct current (DC) fleet of traction motors found on the

What is an impedance bond?
Most railroads use track circuits to determine the location of trains. Tracks are divided into insulated blocks that have separate electric circuits (AC current). If a train is present, the wheels connect two tracks and short out the circuit. Impedance bonds are used to connect the insulated tracks in order to allow the passage of DC traction current but not the AC signal used for locating purposes. Electrical impedance is the frequency-dependent measure of the voltage-to-current ratio that determines how much AC and DC current can flow for a given voltage.

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The new Sulzer impedance bond has an additional multiturn winding that is resonated at 50Hz by an adjustable capacitor. This capacitor is housed either within the bond or in a nearby trackside shelter. The resonating bond achieves the same impedance with fewer winding turns. In fact, Sulzer even achieved impedance that is ca. three times greater than that of a non-resonated bond. As the winding’s length and resistance are reduced, the bond can carry considerably higher traction current without overheating.

earlier trams. Melbourne Service Center has been servicing and repairing traction motor equipment for decades. The service center has grown with the demand and changing technologies; it has moved from a small workshop in Fairfield to new, modern facilities in Laverton North.

The new service center experienced a large increase in its traction repair business during 2010. It was awarded an exclusive contract for the service and repair of traction motors and motor/alternator sets from the heavy rail sector. This contract has been due, in part, to the ever-increasing services being run on the current rail network and the push by the state government to attract commuters to use public transport by offering services that are more reliable.

A completely new challenge
In 2012, an existing customer approached Melbourne Service Center to ask whether Sulzer could undertake the service and repair of impedance bonds for the rail network infrastructure. This was a completely new challenge.

An impedance bond is used on most electrified rail tracks to create a continuous path for electric current around insulated joints and junction points within the rail track. The bond provides the return propulsion current for the traction motors and confines the alternating-current signaling energy to its own track circuit (see infobox on page 5). The bonds are constructed of a heavy, laminated iron core through which a large cross-sectioned copper coil of low resistance and relatively high reactance is placed.

After undertaking many successful repairs to the existing older design impedance bonds, Sulzer’s Melbourne Service Center was approached by Victoria State railway engineers to help them review the design of the 2000 amp bond. The request was issued because of the poor reliability being seen on the installed fleet of impedance bonds. The bonds are situated on the rail tracks in the open. So, they are subject to the rigors of the harsh Australian weather—with temperatures on summer days sometimes in the high 40 °C, but on cold and wet winter days often dropping into the minus figures. This weather had the effect of dramatically altering the impedance value on the original bonds used on the rail system. With the impedance value fluctuating, problems ensued and resulted in frequent failures.

Taking up the challenge, Melbourne Service Center carried out a thorough in-house review of the design of the bond including the insulation system used on the currently installed impedance bonds. Utilizing similar processes developed by Sulzer over many years of undertaking electrical repairs and improvements to rotating machines, the team was able to overcome issues found with the existing insulation system and basic design. Clearly, the biggest challenge was to understand the failure mechanisms of these bonds and to map out the root cause of the failures. The main contributing factor was the inability of the old design to sustain continued exposure to the harsh operating environment in which the bonds had to operate. The usual culprits—moisture, contamination, and heat—topped the list.
**Reliable and robust redesign**

Once the engineers understood the root cause of the failures, the redesign was straightforward. At the same time, the goal was to set a new standard of reliability. Sulzer started by improving the design of the steel housing. The redesign allows for more air circulation with the ability to ventilate the heat generated by the bond whilst minimizing the possibility of water ingress from inclement weather. Next, the team performed a complete review of the raw materials used in the bond assembly and decided that all of the raw materials being used on the original bond needed to be upgraded. The old insulation system was somewhat hygroscopic. It had to be replaced with something that would resist moisture ingress and be of a much higher thermal class than the original insulation. The original copper conductor was replaced with a high-grade, high-conductivity copper conductor from one of Sulzer’s approved suppliers. The engineers sought out the most suitably grained steel laminations and had the “C” cores manufactured to tight tolerances. That allowed better control over the tuning gap required by the two core halves. Even the steel straps that hold the core together were upgraded to a high-quality stainless steel. Once carefully assembled and finely tuned, the bond is then completely vacuum pressure impregnated with high-temperature class resins. This final stage not only bonds the entire assembly together both electrically and mechanically, but also eliminates the chance of rust growing within the tuning gap. This improvement changes the characteristics of the bond giving the new bond a far more robust design.

**A total success**

The first completely Sulzer-manufactured impedance bond went into service in 2012 for type testing by the State Railways on their network. The new impedance bonds were very successful. In fact, the model 2000R impedance bonds have proved to be extremely reliable with no reported issues to date. As a result, Melbourne Service Center was granted type approval for the 2000R impedance bond in 2013 for use on the Victorian State railway network. Since the successful type testing, Melbourne Service Center has now supplied over 140 new 2000R impedance bonds that were manufactured in house in the 24 months that followed the type approval. With an additional 120 in production in 2015, Sulzer also continues to service and repair the older fleet of 1000 and 2000 amp impedance bonds, which are gradually being replaced by the 2000R. Melbourne has an installed base of approximately 2500 units and plans expansions to the current rail network. Therefore, the need for impedance bonds will continue to grow, giving Sulzer more opportunities to supply the new model and keep Melbourne moving.

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Melbourne’s rail network consists of 16 metro lines and 25 tram routes.