Office of the Chief Investigator
Transport Safety

Rail Safety Investigation
Report No 2010/15

Locomotive Fire
V/Line Passenger Train
Marshall Railway Station
30 December 2010

TABLE OF CONTENTS

THE CHIEF INVESTIGATOR

The Chief Investigator, Transport Safety is a statutory position under Part 7 of the *Transport Integration Act 2010*. The objective of the position is to seek to improve transport safety by providing for the independent no-blame investigation of transport safety matters consistent with the vision statement and the transport system objectives.

The primary focus of an investigation is to determine what factors caused the incident, rather than apportion blame for the incident, and to identify issues that may require review, monitoring or further consideration. In conducting investigations, the Chief Investigator will apply the principles of 'just culture' and use a methodology based on systemic investigation models.

The Chief Investigator is required to report the results of an investigation to the Minister for Public Transport or the Minister for Ports. However, before submitting the results of an investigation to the Minister, the Chief Investigator must consult in accordance with section 85A of the *Transport (Compliance and Miscellaneous) Act 1983*.

The Chief Investigator is not subject to the direction or control of the Minister in performing or exercising his or her functions or powers, but the Minister may direct the Chief Investigator to investigate a transport safety matter.

EXECUTIVE SUMMARY

On 30 December 2010, a Warrnambool-to-Melbourne V/Line passenger train suffered a fire on the locomotive at Marshall railway station. The fire was attended by the Country Fire Authority (CFA) and the locomotive and train were subsequently permitted to continue to Melbourne. There were no reported injuries.

The investigation found that the locomotive had been operating with a pre-existing equipment defect; a fault in the dynamic braking system. The locomotive had been mistakenly removed from a repair facility and placed into operation prior to receiving the remedial attention intended. The fire occurred as a result of the unattended defect.

Since the incident, a process has been developed to prevent rolling stock from being operated when it is under attention for maintenance or repair. V/Line have drawn their locomotive and train drivers' attention to the requirement to properly record fault events in the Locomotive Fault Report Book, and has undertaken to develop a process to improve the response of fleet management personnel to situations where vehicles that are logged as being defective are found to still be in service.

The investigation makes recommendations regarding the maintenance of the N-class locomotive dynamic brake cooling fan, the set-up of the dynamic brake grid protection system, and the development of procedures relating to the return-to-service of rolling stock that has been the subject of maintenance.

1. CIRCUMSTANCES

On 30 December 2010 at around 1936 hours, the driver of V/Line locomotive N464 reported an on-board fire after stopping at Marshall railway station on the Warrnambool line. The locomotive was operating scheduled V/Line passenger service № 8250 from Warrnambool to Melbourne Southern Cross Station. The fire was found to be in the locomotive's dynamic brake grid assembly (see section 2.4.2).

Locomotive N464 had previously operated a return trip from Southern Cross Station to Swan Hill on 28 and 29 December during which its dynamic brake system became unserviceable. The driver reported this to the CARS office (see section 2.1.2) en route to Swan Hill and as a result, upon its return to Melbourne the locomotive was inspected and found to have suffered a structural failure of its dynamic brake grid cooling fan. The locomotive was removed from service and dispatched to the West Melbourne Depot for repairs to its dynamic brake grid assembly and replacement of the damaged dynamic brake cooling fan. However, on 30 December 2010, before the locomotive could be attended-to it was removed by V/Line operations personnel without the authorisation of the maintenance contractor and placed on a service to Warrnambool and return.

There was no notification provided to the various locomotive drivers involved in the running of the Warrnambool service that the unit had a defective dynamic brake. As the train approached Marshall railway station near Geelong on its return from Warrnambool, the locomotive driver sought to use dynamic braking to assist with the station stop. Although the cooling fan was defective, the protection system designed to prevent the operation of the dynamic brake under such circumstances did not function and braking was able to be initiated. As a result, a fire was reported that resulted in the detraining of 140 passengers and attendance by the CFA.

There were no reported injuries and passengers were transferred to buses. The train eventually continued empty to Melbourne and the locomotive was again sent to the West Melbourne Depot where it was examined by investigators.

2. FACTUAL INFORMATION

2.1 Fleet management

2.1.1 Background

V/Line Passenger Ltd operates a regional public transport rail and road network throughout Victoria. Operations are based upon a Network Service Plan, the execution of which is vested in the Daily Operations Manager.

2.1.2 The CARS office

This V/Line office exists to coordinate the management of daily passenger car, railcar, and locomotive fleet activities. These activities include fleet rostering, defect recording and maintenance planning, fuelling, and on-train incidents. This office manages the Locomotive and Carriage Rostering System database (LACRS), incorporating the Fault Management System. The CARS office, the BVM maintenance coordinator (see section 2.1.3) and two Yardmasters are located on the same floor of the Southern Cross Station Yard Office.

One Yardmaster is responsible for managing operating staff and rolling stock; the other for managing yard shunting staff and the planned movement of rolling stock in and out of Southern Cross Station platforms.

2.1.3 Maintenance

V/Line rolling stock fleet maintenance is currently contracted to Bombardier Transport Australia under a franchise arrangement that trades as BVM. Some of the maintenance work is sub-contracted to Downer EDI Rail, the previous franchisee. Clyde Engineering (the Australian licensee for the then Electro-Motive Division of General Motors USA, and forerunner to Downer EDI Rail) built the N-class fleet. Within the Greater Melbourne area maintenance for this fleet and other V/Line rolling stock occurs at a number of separate facilities:

1. Newport Workshops (operated by Downer EDI Rail): heavy maintenance

2. West Melbourne Depot (operated by Bombardier V/Line Maintenance): frontline maintenance

3. South Dynon fuel point, originally a component of the South Dynon Locomotive Depot (now operated by Bombardier V/Line Maintenance): servicing and provisioning

4. Dynon Maintenance Centre, originally a component of the South Dynon Locomotive Depot (now operated by Downer EDI Rail and part sub-leased to Bombardier V/Line Maintenance): frontline maintenance

5. Southern Cross Station: minor remedial activity undertaken by Bombardier V/Line Maintenance at platforms or nearby sidings.

V/Line have formal procedures that address the management of rolling stock maintenance requirements that are used by CARS to manage these processes and that list each step in these processes in detail. The procedure, *Planned and Unplanned Fleet Maintenance on Service Availability* (document OPPR-062, 25/02/2008, Rev. 01), provides direction for the CARS office staff on the process by which the fleet is managed in order to maintain scheduled services if rolling stock is unavailable through either planned or unplanned maintenance.

This procedure also describes the actions to be taken by the CARS office to manage planned yearly, monthly and daily maintenance and outlines the responsibilities of the CARS office and maintenance staff involved, particularly those related to recording of information and fleet availability in LACRS.

2.1.4 Management of the movement of vehicles to-and-from the West Melbourne Depot

Placing and Clearing Vehicles at the Bombardier West Melbourne Depot (document OPPR-161, 23/11/2010, Rev. 02) covers the process required for vehicles to enter and exit the depot. This procedure requires that for Sprinter and V'Locity units the driver obtains a ready-to-go certificate from the Bombardier foreman. There is no similar requirement for locomotives.

Marshalling, Shunting and Docking Vehicles in the Bank Sidings (document OPPR-164, 23/11/2010, Rev. 02) describes the requirements for the safe movement of rolling stock within the sidings adjacent to the West Melbourne Depot. The procedure applies to all movements that occur within the Bank sidings, and is triggered by the day-to-day requirements of the Network Service Plan, LACRS, Daily Alteration, Daily Shed Orders (maintenance planned for the day) and the unplanned movements of defective rolling stock.

These procedures list in detail the movements required, the manner in which they will be effected, and the responsibilities of those involved. The procedures do not require that drivers obtain ready-to-go or similar certification before vehicles are moved.

The investigation was advised that there was no procedure requiring that locomotives and railcars undergoing maintenance or servicing attention have temporary signage or placarding placed at the driver's position to indicate they are not to be operated. Yardmasters rely on the amendment of Shed Orders that are updated from LACRS as the day progresses. More importantly, if locomotives might have been in the Bank sidings and the Shed Orders in the shunters cabin are not updated to reflect this, then such instances as the wrong unit being taken and placed on a train, as happened on the 30th December, could occur.

2.2 Development of the incident

The information presented in this section was sourced from interviews and material provided by V/Line.

28 December 2010

When the locomotive driver operating the 1817 Southern Cross Station-to-Swan Hill train set up dynamic braking on the approach to Watergardens (Sydenham), he heard a loud noise that he thought came from the traction motor(s) beneath him. The locomotive sustained a Ground Relay (GR)[1] intervention that the driver reset, subsequently stopping at Watergardens railway station using the air brake.

The driver again used dynamic braking to assist with slowing down on the approach to both Sunbury and Gisborne. At these locations, he experienced no dynamic brake problem or GR event.

The locomotive experienced another GR event when the driver set up dynamic braking on the approach to Woodend. He reset this fault and chose not to use dynamic braking approaching Kyneton. He did though, attempt to use it again on the approach to Bendigo, but the associated GR event was enough to convince him not to try again. He stopped at Bendigo using the air brake and did not use dynamic braking again for the remainder of the trip to-and-from Swan Hill.

During this time, the locomotive driver was unaware of the structural failure of the grid blower fan blades or where this failure may have occurred. At around 2208, while still en route to Swan Hill, the driver advised the CARS office of the dynamic brake fault. The driver did not record any of these events in the Locomotive Fault Report Book as required.

Consistent with standard procedure for any fault matter related to the dynamic brake, the CARS office entered the fault into the LACRS database as a repair task, withdrawing the unit from service on arrival in Melbourne with the notation 'Wait Test Run'.

29 December 2010

At around 1131, the return service from Swan Hill arrived at Southern Cross Station where locomotive N464 was inspected by a diesel maintainer. The BVM Station Coordinator added 'Out of service – requires new grid blower' to the Fault Management System (FMS) file created in LACRS for this fault event. The Activity Code and Description column has the comment 'To Newport' added, but V/Line personnel could not say if this notation was added on the 29 or 30 December (that is to say, before or after the Warrnambool trip and dynamic brake fire).

The entries made to the Loco Daily Roster regarding the next planned movements for N464 were inadvertently transposed (swapped with another locomotive) and a fuelling requirement added, since N464 had accumulated over 1200 km upon its return from Swan Hill.

[1] An earth fault overcurrent protection device provided in locomotive high-voltage circuits. It is designed to protect electrical equipment, especially traction equipment, against damage from spurious short circuits and so-called 'power grounds' (potentially unsafe leakage of current between the traction circuits and the locomotive structure). Operation of this protective device will remove the electrical propulsion of the locomotive. On the N-class locomotive the device will 'latch-out' and must be reset to enable continued operation.

A number of regular BVM staff at the West Melbourne Depot, including the V/Line-BVM Maintenance Coordinator (a V/Line officer) were on leave at this time. The relief V/Line Maintenance Coordinator and the BVM Station Coordinator at Southern Cross Station were the only people providing information regarding locomotive movements and Newport Pilot (locomotive) requirements during the Christmas/New Year period.

Locomotive N464 was placed at the Bank sidings adjacent to the West Melbourne Depot where it was examined by BVM shop staff.

At approximately 1800 a formal request was made from the CARS office to the BVM Southern Cross Station Coordinator for the locomotive to be placed to the West Melbourne Depot on 30 December. However, the Shed Orders for 30 December were not amended to reflect this as there was no-one on duty to do so. It is therefore not apparent who, if anyone was informed of this request.

30 December 2010

Early in the morning, N464 was removed from its temporary storage position in the Bank sidings and taken to the South Dynon locomotive depot for fuel (at the Yardmaster's instructions per the LACRS requirement placed on the file the previous day). With fuelling completed it was returned—along with another locomotive per Yardmaster's arrangements—and placed in the Bank sidings. There were no prior arrangements regarding placing N464 into the West Melbourne Depot and this was consistent with the Shed Orders not having been updated to reflect this request.

At around 1430, the Yardmaster requested a swap involving N451 and another locomotive (which was unable to be determined) in the Bank sidings for afternoon departures. Since N451 was rostered in LACRS for the 1300 Warrnambool it can be surmised that the unit chosen (by whom was not determined) was N464 and that N464 had been mistakenly dispatched on the 1300 Warrnambool service. With N464 now en-route to Geelong, CARS officers decided that all that could be done was to update LACRS. None of the locomotive drivers involved with movements of N464 prior to and during this run were advised of this situation.

2.3 Personnel

The locomotive was operated on both the Swan Hill (28–29 December 2010) and Warrnambool (30 December 2010) return journeys by drivers who were appropriately qualified and currently assessed as competent and medically fit for duty.

During its trip from Melbourne to Warrnambool and back, locomotive N464 was operated by five separate drivers, these being: (1) the driver who retrieved it from the workshops locality, placed it to the platform at Southern Cross Station, and coupled it to the train; (2) the Geelong-based driver who operated the train from Southern Cross Station to Geelong; (3) the Geelong-based driver who forwarded the train from Geelong to Warrnambool; (4) a third Geelong-based driver who operated the train from Warrnambool back to Geelong; and (5) a fourth Geelong-based driver who operated the train from Geelong into Melbourne (in this case running as empty cars since the passengers had been transferred by bus). None of the first four of these drivers had been advised of a dynamic brake fault on this locomotive and none were aware of the issue until it became apparent to the fourth driver.

The locomotive driver operating the return journey from Warrnambool stated that he used ”light” dynamic braking throughout the journey to Marshall to control train speed for brief periods on various descending grades. After using dynamic braking to assist with slowing and stopping at Winchelsea railway station, he noticed a slight burning smell, but nothing appeared out-of-course and a cursory look-back did not reveal any residual smoke or any fire. As a result, after the station stop he continued towards Marshall. There were no other warning symptoms or alarms. He used dynamic braking again to stop at Marshall railway station and immediately noticed the fire in the locomotive's dynamic brake grid area after stopping.

2.4 The locomotive

2.4.1 Overview

Locomotive N464 is one of a class of diesel-electric locomotives built under licence to the Electro-Motive Division of General Motors (EMD-GM) of the United States of America (U.S.A.) by the Clyde Engineering Company at Somerton, Victoria. They were placed into service by V/Line between 1985 and 1987, and the units are nowadays dedicated to the operation of passenger trains.

Figure 1 - An N-class locomotive, with the air intake to the dynamic brake grids circled

2.4.2 The dynamic brake system

As an operating function, dynamic braking is secondary to the normal air brakes. Locomotives with defective dynamic brakes can still be operated safely so long as the air brake system is fully operative.

Six traction motors—one per axle—are supplied with electrical energy from the locomotive main alternator (driven by the diesel prime mover) in order to power the locomotive. Under dynamic braking, the electrical relationship between the traction motors and the main alternator is altered such that the traction motors become generators. A characteristic of this conversion is that an electrical field—the strength of which is controlled by the locomotive driver—is applied to the traction motors. This electrical field resists and tends to retard the rotation of the traction motor (and therefore the speed of the train), acting as a variable braking force and generating an electrical output that is fed to heavy resistance grids where it is converted to waste heat.

2.4.3 Dynamic brake grid blower

To prevent their destruction by the high temperatures created, the resistance grids are cooled during dynamic brake operation by a large fan that draws ambient air through the grids and exhausts it above the locomotive, driving grid heat to atmosphere. An electrical connection across one of the resistor grids is used to power the fan motor.

The N-class locomotive dynamic brake grid blower assembly consists of a 10-bladed fan powered by a direct-current electric motor. This motor is contained within a tubular frame that is suspended from three sets of radial support arms that carry a ring-shaped fan frame. The fan rotates within the fan frame, which is the mounting point for the blower assembly to the roof of the locomotive.

Figure 2 - Dynamic brake grid blower assembly showing component parts

A manufacturer's Maintenance Instruction draws attention to "A particularly integral relationship [that] exists between the grid blower fan and grid resistor..." and that "Proper maintenance of the cooling fan motor components...." is stressed. This instruction also states that "...improper maintenance or malfunction of fan motor and related equipment is the major cause of dynamic brake grid failure."

2.4.4 Grid blower protection

The technical manual for the locomotive describes a protective circuit that drops the electrical feed to the brake relay should the blower motor fail to operate. Excessive dynamic grid current (caused by a stalled grid blower, or lack of motor current) will be detected by a current-metering device, triggering the cessation of dynamic braking and preventing its further operation until reset. However, in this incident there was no evidence to indicate the development of excessive grid current.

2.4.5 Dynamic brake grid protection

The N-class locomotive incorporates grid protection to guard against overheating of the resistance grids. Arising from characteristics of the grid material, higher grid temperature causes greater grid resistance, and a corresponding increase in the grid voltage-to-current ratio. Electrical parameters monitored within the system should—when design limits are reached—trigger the cessation of dynamic braking, thus preventing the grids from reaching an unacceptable temperature.

When grid cooling is lost, as in this instance, it would be expected that this protective system would shut down dynamic braking prior to the grid reaching a potentially destructive temperature.

Following this incident, BVM reviewed pertinent technical documentation. They believe this protective system can in fact function such as to permit the selection of dynamic braking by the locomotive driver and its operation for a brief period (the extent of which depends upon the amount of braking effort being requested) until the grids reach a potentially damaging temperature. Thus, for short durations or at a minimal braking call, dynamic braking could still operate even if the grid cooling fan is inoperable.

At a certain grid temperature, the protective circuit should operate to discontinue dynamic braking. BVM have identified the need for a procedure to test for this functionality but have yet to design a process by which this can be accomplished without risking damage to or destruction of the grids.

2.5 Dynamic brake cooling fan failure

2.5.1 Overview

The refurbished fan that failed in this case was installed in locomotive N464 in May 2006. The fan was subsequently checked approximately every five months as part of the locomotive examination schedule; the most recent checks prior to the incident being on 21 October 2010, slightly more than two months prior to the incident. Fan blade inspection is not identified as a requirement of scheduled maintenance between overhauls.

2.5.2 Post-incident contractor inspection

The dynamic brake fan from N464 was sent to the repair contractor who reported that no fault could be found with the motor or bearings that might permit sufficient free play within the motor to have allowed the fan blades to contact the frame.

2.5.3 Workshop inspection

A mesh-style protective grille, usually situated above the fan and mounted to the fan frame was not in place and there was no record of it having been identified as missing prior to this incident. The grille was not recovered.

Figure 3 - Damaged fan assembly, showing direction of rotation of fan and frame

It was apparent that the circular fan frame had rotated at least a quarter of a turn in the clockwise direction. All eight bolts securing this frame to the roof of the locomotive were missing. The electrical connections to the fan direct-current motor had been wrenched and separated.

Two fan blades had fractured and were missing, believed to have been ejected after their separation. The stubs of the missing blades—forming part of the blade-to-hub mounting base—were removed for metallurgical assessment.

Light but recent abrasion damage was evident along the upper trailing edge surfaces of the remaining eight blades. The leading-edge tips of these eight blades had all been bent upward, with corresponding heavy abrasion damage to the underside of each tip and at the outer ends of all six frame support arms.

There was impact damage and associated deformation of one of the fan frame support arms and the trailing blade stub (Figure 3, blade № 1) had been bent upwards, with corresponding evidence of cracking across the hub surface.

Figure 4 - Deformation of fan frame support arm and cracking of hub

2.5.4 Metallurgical assessment of blades

The two fractured blade stubs were submitted for metallurgical testing and an evaluation of materials, hardness, potential manufacturing defects and fracture mechanisms.

The blade material was found to be consistent with a UNS A92219-grade aluminium alloy. This material is used for structural applications at temperatures to 315 degrees Celsius and was considered by the testing laboratory to be appropriate for the application. The hardness results were consistent with those expected for the material and the microstructure of the fractured blades and as expected for the material in the as-manufactured (forged) and aged condition. Metallurgical forging defects were not detected in the microstructure. In summary, the material properties were considered unlikely to have contributed to the development of the fatigue crack that led to the eventual separation of the leading blade.

The fracture surface of the stub from the leading fractured blade (Figure 3, blade № 2) was assessed. The cracking mechanism was found to have derived from fatigue and ductile overload. The small amount of ductile overload fracture at the trailing edge suggests that the fatigue fracture had occurred through a low-stress/high-cycle mechanism, indicating progression of the fatigue crack over a significant part of the service life of the component.

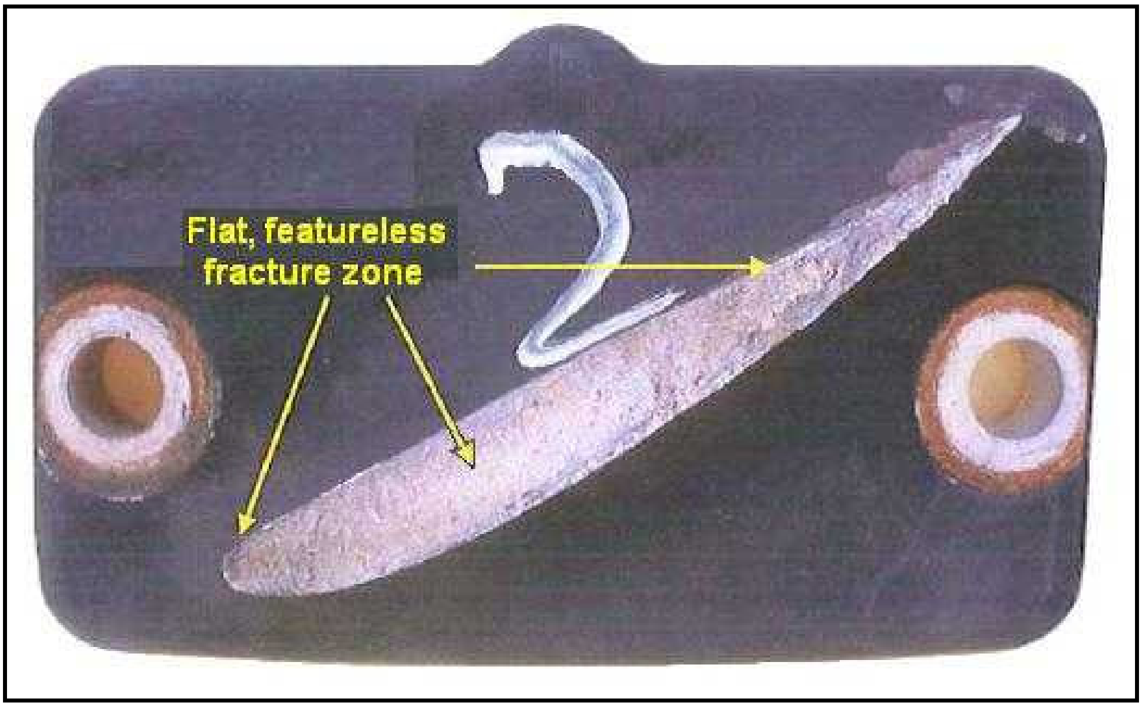

Figure 5 - The fracture surface of the leading blade - note the flat featureless zone (fatigue crack) through to fibrous ductile fracture at the trailing edge

The fracture surface in the vicinity of the fatigue fracture origin did not show any signs of pitting or surface indentation that could have contributed to stress concentration in the fatigue mechanism. There were also no metallurgical defects identified that could have contributed to the fatigue failure mechanism. There were signs of slight mechanical damage at the origin of the fatigue fracture. However, without the remainder of the separated blade, the testing laboratory did not form an opinion as to whether this damage could have been present prior to the initiation of the fatigue crack.

The testing laboratory considered that potential contributors to the cracking of the blade included external factors such as higher-than-design fatigue loading, the fatigue limit of the material being exceeded during the service life of the blade, and high residual stresses as a result of fabrication techniques or bending and/or straightening during service maintenance.

The fracture surface of the stub from the trailing fractured blade (Figure 3, blade № 1) was assessed. The mechanism by which cracking was induced was found to be consistent with instantaneous ductile overload. It was considered likely that this fracture had occurred as a result of an external force.

2.6 Dynamic brake fan design and maintenance

2.6.1 Design

On referral from BVM, investigators contacted the previous maintenance contractor for the N-class fleet, Downer EDI Rail, who in turn contacted EMD[2], the original equipment manufacturer, for advice on aspects of fan design and recommended maintenance. EMD did not respond to requests for information on:

- The specified design life of the fan or whether the units could be repeatedly refurbished as long as they continued to meet service manual specifications
- Whether the fan blades have a specified design life related to cyclic loading and its effect on metal fatigue
- Any known history in Australia or internationally of fatigue failure of fan blades of the type of fan (or similar) fitted to the V/Line N-class locomotive
- Whether or not they recommended a particular regime for the periodic inspection of fan blades and if so, what the period might be.

The investigation was unable to resolve questions related to the design and fatigue life of blades used in the dynamic brake cooling fan assembly fitted to N-class locomotives.

2.6.2 Maintenance

BVM advised that the dynamic brake fans used on the N-class locomotive fleet are changed-out nominally every ten years and replaced with units refurbished by a local contractor. The investigation was informed by BVM staff that there is no limit to the number of times a dynamic brake fan can be refurbished and returned to service.

The contractor, who for the past 20 years has overhauled fans of this type, advised that refurbishment is performed in accordance with the manufacturer's maintenance instruction for the dynamic brake grid fan and motor. As part of this refurbishment, fan blades are visually inspected for damage but there is no other specific inspection or test aimed at detecting the presence of cracks. The contractor also commented that blades are sometimes chipped or have minor damage, but that they could not recall ever servicing a unit with a cracked blade. The contractor noted that when the fans are received for servicing, the blades have usually already been painted.

Downer EDI Rail supplied the investigation with a copy of a fan maintenance instruction specifying a scheduled maintenance program for U.S.A. domestic locomotives with the same components as the N-class. Among other maintenance requirements for dynamic brake components, the instruction specifies renewal of the dynamic brake cooling fan assembly at a six-yearly interval. There is no specific reference to inspection of fan blade condition.

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[2] Electro-Motive Diesel, Inc – the successor to EMD-GM

3. ANALYSIS

3.1 Incident summary

The dynamic brake cooling fan on locomotive N464 had suffered a structural failure. Although the time and location of this event could not be determined, it is considered possible that it failed at the time a loud noise was heard by the driver after applying dynamic braking as the train approached Watergardens. As a result of the unserviceability of the fan, the dynamic braking functionality of the locomotive was adversely affected and this was reported to the CARS office by a driver before arrival at Swan Hill. In accordance with procedures, the locomotive was returned to Melbourne with the dynamic brake 'out-of-service'.

On arrival in Melbourne, the fault was identified by maintenance staff and the locomotive was dispatched for repair, although this fact was neither properly recorded in the fleet management database nor conveyed correctly to operational staff. As a result, before the fault could be attended-to by maintenance personnel, the locomotive was removed from the facility, fuelled and placed back into service.

During its next run, the dynamic brake was used by drivers and subsequently a fire occurred in the dynamic brake equipment space due to the grid cooling fan being inoperative and the grid protection system not operating as expected. It is apparent that so long as the driver used dynamic braking at a minimal level and for relatively brief periods, the resistor grids were able to sustain the electrical load without a destructive rise in temperature and it was only at Marshall that a fire eventually ignited.

Regarding the fire itself, temperatures reached in the grid were sufficient to initiate combustion of materials contained within the grid or its vicinity, but were not so great, or the fire of such intensity, for the grid to melt or be completely destroyed.

The most significant feature of the circumstances surrounding this incident is that an unserviceable locomotive was mistakenly placed into passenger service. The result was a fire, which was relatively easily controlled. However, under different circumstances the outcome could have been far more serious.

3.2 Fleet management and the fault database

3.2.1 Procedures

The Yardmasters who, through liaison with the CARS office, provide the day-to-day instructions to operating staff regarding locomotive assignments and required depot movements, are reliant on a 'manual' system (Shed Orders requiring to be manually updated) that appears to coordinate unconvincingly with LACRS.

It is apparent that no 'handover/handback' procedure existed between V/Line and its maintenance providers by which the management of fleet assignments could be assured throughout the process. This, particularly in a public transport business, should have been considered unacceptable. The investigation was advised that this matter is being addressed. Also, there was no formal safety process in place by which locomotives and railcars were placarded or otherwise denoted as 'not to enter service' while awaiting maintenance attention. Such a process is a basic safety mechanism applied elsewhere in the rail industry.

The critical interface between the CARS office and field supervision is neither clearly defined nor rigorously executed. The effect is to permit process to occur in an imprecise fashion that exposes the operation to potential safety risk. Although V/Line has ensured that all of its processes related to moving rolling stock into and out of the Bank sidings are documented in detail, the critical element of clearly prescribing a chain of approval is not directly articulated. Whereas the procedures concentrate on who gives authority to whom to move a vehicle up to and beyond a signal or set of points, or from one place to another, they do not manifestly describe how vital permissions and approvals are communicated so that the movement of the correct rolling stock is ensured, and irregular or unintended movements precluded.

3.2.2 Actions after realising error

The inadvertent swapping of the two locomotives was discovered after locomotive N464 had been dispatched on the run to Warrnambool. However, no attempt was made to advise any of the drivers involved with the handling of this locomotive of the dynamic brake fault. That a locomotive, particularly one in passenger service, could be allowed to continue in operation without drivers being made aware of its deficient serviceability state should not have been allowed to occur.

3.3 Driver locomotive fault recording

Locomotive drivers are required to record Ground Relay events and dynamic brake faults in the Locomotive Fault Report Book. In this incident, that action was not taken by the Swan Hill driver. A fault report entry is the only notification a subsequent driver will receive about a locomotive's serviceability and maintenance history before it is operated. In this incident, the recording of the dynamic brake fault may have prevented the removal of the locomotive from the facility, or subsequent drivers using the dynamic brake.

3.4 Dynamic brake fan

3.4.1 Fan failure

The investigation found that the first fan blade to fail was the leading blade (Figure 3, blade № 2) of the two that failed; as a result of fatigue fracture. The investigation concluded that this blade then fell between the fan frame and the following blade (Figure 3, № 1) causing the fan frame mounting bolts to shear, the frame to rotate and the second blade to fail in overload. The fan motor electrical connections were separated at this time.

The cause of the fatigue crack in the leading blade could not be determined with any certainty, although it is possible it was initiated by mechanical damage at some point in the blade's service life.

Following a review of the Fault Management System, BVM stated that there had been no reports relating to the dynamic brake fan on this locomotive in the previous month and that there was no scheduled maintenance task that might have required the grille to be removed (and thus not replaced). In addition, observations of the grille retaining clips on the fan frame revealed damage possibly consistent with the forced or violent removal of the grille.

3.4.2 Fan maintenance

Fan blade condition assessment is limited to visual inspection at major overhaul intervals. It might be expected that repainting an overhauled component would be the responsibility of the overhauling contractor; however, these fans are cleaned and painted prior to dispatch for overhaul, effectively concealing any critical defect that might otherwise be visible to the contractor.

An EMD maintenance instruction speaks of a critical need to ensure proper maintenance of the dynamic brake grid system and associated equipment (including cooling fans, regulators, and cabling). The instruction provides a troubleshooting checklist for the fan motor and resistor grid assembly but does not provide specific comment on the fan and hub sub-assembly. Nevertheless, the fan proper could reasonably be considered to be ‘associated equipment’.

The current maintenance practice of renewing the dynamic brake cooling fan at about 10-year intervals is inconsistent with the six-yearly interval specified in the maintenance instruction for U.S.A. domestic locomotives with a similar component.

3.4.3 Dynamic brake grid protection

The dynamic brake grid protection system monitors grid temperature by monitoring its resistance. If temperature rises above a pre-determined value, the system removes main generator excitation and de-energises the dynamic brake power relay. The braking power contactor thus drops out to protect the resistor grids from burn-out due to overheating. An absence of grid cooling might be expected to lead to such a shut-down.

In assessing this incident, the current fleet maintenance contractor believes this protective system can in fact continue to function such as to permit the selection of dynamic braking by the locomotive driver and its operation for a period of time until the grids reach a potentially damaging temperature. It is therefore possible for dynamic braking to continue to operate even if the grid cooling fan is inoperable.

BVM have identified this anomaly and the need for an exploratory test procedure to examine this functionality. They have yet to design such a process that can be used without risking damage to or destruction of the grids. Efforts in this direction are described by BVM staff as ‘work-in-progress’.

Despite an engineering review of relevant circuit diagrams and manuals, and discussions with BVM personnel, the investigation has not been able to ascertain exactly why the grid protection system did not detect the increasing grid temperature prior to the initiation of a fire. The investigation has concluded that the most likely scenario is that the electrical parameters being monitored did not reach the threshold to initiate dynamic brake shut-down.

3.4.4 Dynamic brake grid fire

A localised area of scorching and distortion of the locomotive hood superstructure was evident, indicating the high temperatures sustained by the resistance grid during overheating. However, the grid assembly itself suffered relatively minor damage from the high temperature and did not show signs of any significant fire. The dynamic brake resistance grid assembly is not comprised of materials that can readily combust. Any flames observed by the locomotive driver may well have been the product of foreign material (probably organic matter) that could have collected within the grids and the dynamic brake hatch during normal service. It is unlikely that this material would have fuelled a fire that lasted for a period that was reported to be in excess of ten minutes.

4. CONCLUSIONS

4.1 Findings

1. The dynamic brake grid protection system failed to prevent the resistance grids from attaining a temperature sufficient to cause ignition of proximate combustible materials.

2. There is no formal maintenance requirement for an inspection mechanism capable of identifying the existence of any structural fault within a dynamic brake cooling fan blade.

3. The scheduled maintenance interval for replacement of the dynamic brake cooling fan assembly on N-class locomotives differs from that applied to similar equipment in the U.S.A. (the country of manufacture).

4.2 Contributing factors

1. Imprecise administration procedures permitted the wrong locomotive to be placed into service.

2. V/Line had no 'tag-out' or safety protection system placed on or about the locomotive that would have prevented it from being put into service before repairs were completed.

3. No entry was made in the Locomotive Fault Report Book related to the dynamic brake fault on 28 December 2010.

4. Locomotive N464 was inadvertently removed from a repair facility and placed in service in a defective state.

5. Once the inadvertent swapping of two locomotives had been detected, N464 was permitted to continue in operation without instruction to drivers to isolate the dynamic brake.

6. The dynamic brake grid protection system did not isolate the dynamic brake before the resistance grids overheated.

5. SAFETY ACTIONS

5.1 Safety Actions taken since the event

5.1.1 Prevention of movement of defective rolling stock

Bombardier V/Line Maintenance has advised they are developing a ‘lock-out’ device for fitment to all rail vehicles. This will permit maintenance staff to lock the brake pipe emergency cock in the ‘Open’ position, preventing it from being charged with air (and thus the vehicle from being operated). One design for each vehicle type is currently installed for trial and feedback from relevant staff.

5.1.2 Recording on-board faults and failures

V/Line has issued a reminder to locomotive and train drivers regarding the recording of fault events and information in the Locomotive Fault Report Book.

5.1.3 CARS procedures

V/Line has undertaken to develop a process to provide CARS personnel with guidance in their response to situations where vehicles that are logged in the Locomotive and Carriage Rostering System as being defective are identified to be still in service.

5.2 Recommended Safety Actions

Issue 1

V/Line has published detailed procedures related to the moving of rolling stock into and out of Bank sidings, but these do not adequately articulate how vital permissions and approvals are communicated such that the movement of correct rolling stock is assured.

RSA 2012008

That V/line develops procedures related to the placing back into service of rolling stock that has received maintenance to ensure that only correctly approved vehicles are used for operations.

Issue 2

The maintenance assessment of dynamic brake fan blade condition is limited to visual inspection at major overhaul intervals. However, prior to inspection blades are painted, which negates the value of any visual inspection.

RSA 2012009

That V/Line considers revising grid blower fan maintenance procedures to facilitate a thorough inspection of fan blades during both in-house inspection and contractor overhaul.

Issue 3

Bombardier V/Line Maintenance advised the investigation that replacement of the dynamic brake cooling fan assembly on N-class locomotives was nominally carried out every ten years. The interval specified by the original equipment manufacturer is six years.

RSA 2012010

That V/Line reviews its policy for the replacement of dynamic brake cooling fans and considers adopting the six-year maintenance interval for renewal of the dynamic brake cooling fan assembly.

Issue 4

After the failure of the dynamic brake grid cooling fan, the grid protection system allowed the grids to reach a temperature sufficient to cause combustion of materials in or about the resistor grids.

RSA 2012011

That V/Line reviews the temperature threshold at which the N-class dynamic brake grid protection system causes the operation of the dynamic brake to cease.