



Netherlands High Speed Rail



Reliability Assessment of AnsaldoBreda V250 Units
Final Report
May 2013

Nederlandse Spoorwegen Financial Services Co
Nationale Maatschappij der Belgische Spoorwegen



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NSFSC
Behan House
10 Lower Mount Street
Dublin 2

NMBS
Hallepoortlaan 40
1060 Brussel

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description	Standard
A	15 May 13	J Brake	M Hampshire S Stretch	P Holder	First Draft for Internal Review	
B	17 May 13	J Brake	M Hampshire S Stretch	P Holder	First Draft for Client Comment	
01	24 May 13	J Brake	M Hampshire S Stretch	P Holder	Formal Issue to Client	

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Executive Summary

Nederlandse Spoorwegen Financial Services Company (NSFSC) and Nationale Maatschappij der Belgische Spoorwegen (NMBS) ordered 19 V250 sets in 2004 from AnsaldoBreda of Italy. They are destined to operate domestic high speed services (250kph) on HSL-Zuid between Amsterdam, Rotterdam and Breda, and linking Amsterdam with Antwerp and Brussels.

The sets entered service in December 2012 and were withdrawn from service in January 2013 after continual reliability problems and further issues linked to snow. Mott MacDonald has been asked to provide an independent opinion on the sets and to advise specifically;

- whether the sets have been designed to the specification;
- whether they have been manufactured to specification;
- their potential reliability; and
- any remedial actions

Mott MacDonald undertook an initial review of reliability data and a series of systems based meetings with key individuals including the reliability task force representatives and the operators. These were used to focus the subsequent more detailed investigations into those areas which had been causing the most significant problems. Further detailed investigations were carried out into;

- Batteries and low voltage control,
- Doors,
- FMECA and Life Cycle Costs.
- Manufacturing,
- Final design quality.

These investigations involved further detailed meetings with AnsaldoBreda and reviews of documentation and train inspections. It is important to note that AnsaldoBreda have co-operated with the review at all times and have provided answers and documents readily and speedily.

Based on the system reviews undertaken, it is Mott MacDonald's conclusion that the sets, excepting the battery issues noted below, substantially meet the specification as agreed between the Awarding Authority and the Manufacturer. There are further non-compliances that were either accepted by the Awarding

Authority for initial service or, are secondary in nature. It should be noted that the Technical Specification is a high level document that requires the Awarding Authority and the Manufacturer to agree subsequently on a number of issues. However, although it is recognised that the design has been accepted through the design review process, there are significant concerns about the configuration of the battery charging circuits in that we do believe that;

- Thermal protection is inadequate
- Isolation of batteries from each other is inadequate
- Low voltage protection is insufficient
- Battery negative earthing is incorrectly configured.

The reported difficulties the units have had with holding charge and also the battery overheating incidents support the need for a re-design in this area.

The manufacturing control process documentation is of a high standard and when sampled shows a high level of completeness. There are concerns that only limited production information has been supplied to the shop floor during manufacture which may have led to some of the variations seen in the final finish of the various sets.

However it is clear that the final finish, despite completed inspection paperwork, is poor in many areas. Arguably there are a number of Contract clauses where this poor finish could be considered to be non-compliant with the contract, although these potential non-compliances are considered to be secondary in nature. The poor quality issues are not consistent between the sets. While no single issue is likely to have a significant reliability implication on its own, the large volume of small problems is likely to lead to reliability issues in the future. The quantity is too large for a practical inspection regime to be implemented in the medium to long term. A remedial action plan is therefore recommended and Mott MacDonald considers this to be a practical approach. This needs to be based on a detailed survey across the fleet, planned modifications and a carefully controlled and audited programme of rectification.

The FMECA and Life Cycle Costing models appear to be carefully constructed in line with the principles in the technical specification. There are odd errors of detail

but nothing significant. It is clear however, that the life cycle cost aspects of the maintenance regime have not yet been proven in practice, and there are some concerns that some times given in the model may be optimistic. It is also clear that access to some systems – doors for example – is difficult.

The process being used by AnsaldoBreda to develop the software baselines is robust and the samples viewed indicate that they are tackling faults indicated to them by way of the TOIL process. It would appear that Baseline 10 will be a significant step forward and will reduce significantly the number of faults logged that are, in fact, issues with logging algorithms rather than real hardware faults. It is Mott MacDonald's view that Baseline 10 should be installed on a number of units and further running undertaken to better understand the true faults on the train.

Finally, it is Mott MacDonald's belief that the majority of ATP problems relate largely to known system issues rather than the train itself.

Mott MacDonald believes that it is technically feasible to create, with AnsaldoBreda, a remedial action plan that rectifies the perceived defects and build quality issues and includes a robust and comprehensive commissioning regime. This will need to be coupled with further test running to ensure that other hardware faults are not being masked by the current issues with the fault logging algorithm. An initial estimate of the timescales for this programme suggest in the region of 17 months is a realistic timescale for fleet wide rectification.

11 Conclusions

Mott MacDonald has undertaken a high level review of a number of aspects of the design and production of the V250 train sets. These are

- The traction, high voltage, medium voltage and low voltage system
- The external door system
- The Fault Modes and Effects Analysis and Reliability calculation
- The life cycle cost model
- The manufacturing quality control process and finish
- The production engineering of the final finish

This section sets out our conclusions from the study.

11.1 Limited Data

- 1 It is clear from early discussions that there is very limited quality download data to support an understanding of traction related problems. While it appears that some of these problems will be eliminated in Baseline 10 more detailed data in this area are required.

11.2 Low Voltage Circuit

- 2 Mott MacDonald has serious concerns about the adequacy of the design for battery charging, low voltage protection, thermal protection for the batteries and the battery negative earthing. Mott MacDonald believes that these areas require re-design and that the four recent battery failures could result from these design flaws.
- 3 It is also more than likely that a significant number of the batteries fitted to fleet may at best require specialist re-conditioning or, at worst, complete replacement.

11.3 Doors

- 4 The design of the doors meets the technical specification and is a proven design from a respected supplier. The outstanding issues are monitored through the TOIL and the processes for managing design change are robust within AnsaldoBreda. They have sufficiently demonstrated that all issues were in various stages of investigation (updates logged on the TOIL) and that two items (step micro switch and O-ring security on inflatable seal) had potential solutions in place which were currently progressing through the change control process.

11.4 FMECA and LCC

- 5 In general, all systems access times would benefit from further physical validation in conjunction with a trial of the guidance given in the maintenance instructions. The access times allocated within the LCC are only estimates based on a combination of supplier information, design documentation, past experience and build processes.
- 6 General equipment accessibility, relating to space and design, in particular for the door pneumatic unit does not meet the full requirements given within the Technical Specification document for sections relating to maintenance and accessibility.
- 7 Guidance given within the maintenance instructions to gain equipment access is very limited and would benefit from more detail.
- 8 It is recommended that a detailed analysis and validation programme be carried out for each individual system to fully validate maintenance and access requirements against those of the Technical Specification.

It is understood from the meeting with NedTrain staff on the 07/05/2013 that the validation process for maintenance and access requirements has started and that AnsaldoBreda's maintenance instructions are being transferred into NedTrain maintenance staff format as part of this process. This process is expected to provide some of the necessary validations required.

11.5 Manufacturing

- 9 The procedures stated in AnsaldoBreda's Quality Plan were reviewed by Mott MacDonald and considered to be comprehensive and in accordance with ISO 9001 standard practices and a sample check of all records indicated that the procedures stated in the quality plan were followed during the production of the V250 trains and were completed and signed off as appropriate by the Awarding Authority.
- 10 The limited information made available to shop floor staff to assist in the assembly of the vehicles was considered to be inadequate when compared to information supplied during manufacture by other rail vehicle manufacturers.
- 11 The focus of the inspection process on systems and components rather than build stages may have reduced the opportunity to view developing workmanship problems.
- 12 All customer MIPs witness inspections point were either signed off by the Awarding Authority inspector as witnessed or signed off as not witnessed and the Awarding Authority signed off all the MIP's inspections, the Customer Release Certificate and accepted vehicles (including an agreed list of outstanding items) delivered to Holland.

- 13 The inspection process, as implemented by AnsaldoBreda and the Awarding Authority, did not achieve what should have been its fundamental aim of ensuring the finished product met the contracted manufacturing requirements

11.6 Final Production Quality

A high level review of the design of the V250 trainsets and the associated quality of the final finishing and workmanship has been conducted.

Please note the limitations identified in Section 10.2.1 and that all findings are based upon the inspection of the identified trainsets only which may, or may not, be representative of the entire fleet. Furthermore AnsaldoBreda activities, which are on-going at Watergraafsmeer Depot for which Mott MacDonald are uncertain of the overall scope, purpose and stage of completeness, may be addressing aspects of the findings of this report.

11.6.1 Visual Inspection Conclusions

- 14 Overall the V250 trainset design presents a modern exterior appearance. The bodysides and general painted finishes, seen by passengers, present a ripple and distortion free perspective. Interiors could be interpreted as functional and adequate but are broadly indifferent in their execution.
- 15 Sound fundamental design principles appear to have been employed by AnsaldoBreda at a high level and the majority of the trainsets core and essential design does not raise major concerns with respect to structural integrity, robustness or safety.
- 16 Many key systems, components and sub-systems are supplied by well-known and reputable manufacturers and suppliers. A degree of confidence therefore exists that such equipment is capable of acceptable performance (disregarding integration issues).
- 17 The physical placement, location and attachment methods of equipment to the main bodyside appear logical and robust.
- 18 Lower level design considerations and more secondary areas of the trainsets design have issues. This is typified by the poor and structurally lacking vehicle end structures which are flawed in most aspects, potentially giving rise to detachment from the train if a hard localised impact is experienced. These are deemed to be unsuitable in both construction and their attachment to the train.
- 19 Cable routings, pipework and cable retention methods when connecting from the underframe to individual pieces of equipment are often executed in a poor and haphazard manner which presents

numerous opportunities for snagging, wearing and damage. Such practices would not be expected from a competent international rolling stock manufacturer.

- 20 It is clear that AnsaldoBreda has recognised a number of shortcomings in relation to final cable and pipework installations and has employed a range of methods to attempt to overcome these. Unfortunately resolution methods are sometimes inconsistent, not always applied and are often executed in a manner which gives a low level of confidence for long term robustness (e.g. rubber patches cable-tied in place to prevent wear. These issues, in aggregate per trainset, present possibly hundreds of specific locations where cabling and pipework is subject to damage and wear. It is not considered feasible to monitor and perform on-going repairs long term on a reasonable and practical periodicity of inspection.
- 21 General quality and workmanship ranges from satisfactory and adequate, in the majority of areas, to poor or sub-standard in localised and specific areas of the trainsets' design. It is suggested that a competent and responsible rolling stock manufacturer would react appropriately to constructive criticism of such areas and as such be willing to work with the purchaser to resolve such issues in an acceptable and mutually agreeable manner.
- 22 The following conclusions have been made with reference to the groupings of the train design as identified in Section 10:
 - a. Vehicle Bodysides
 - i. The side skirt design and the captive nut / bolt design will be prone to damage but it is not so bad as to be classed as not fit for purpose. Locks are for identification of restricted access and will not be robust enough to retain the skirts with the captive bolts removed.
 - ii. Corrosion between the side skirts and the bodyside is likely due to galvanic corrosion in the region of stainless steel rubbing strips.
 - iii. External passenger doors (when open) present the opportunity to collect debris and water above the door opening and may enable passengers to access the innards of the mechanism. This could be a safety concern.
 - iv. Wear to the transfers or vinyl applications on exterior doors indicates that they are easily damaged by the washing machines used, and are therefore either not appropriately specified or applied.
 - b. Bogies
 - i. Robust and soundly manufactured overall.
 - ii. There is excessive packing and shimming on the anti-roll bars which is not normally acceptable.
 - iii. Cabling and pipework connections, terminations and routings are poorly executed in a number of areas. Wearing, snagging and subsequent damage is very likely to occur. Such wearing is already apparent.
 - c. Vehicle Roofs
 - i. A number of pipework runs are not suitably supported even though the opportunity exists to do so.

- d Intermediate Vehicle Ends
 - i The vehicle end structure (up to and below coupler level) is not robust and is flawed in many aspects of its design considering its vulnerability to impact and damage. It is not considered to be suitable for long term operations.
 - ii Intervehicle cabling is installed in a manner which provides a potential 'ladder'
 - iii High voltage cabling is allowed to rest upon or rub against the gangways. Secondary protection, installed by AnsaldoBreda, is sometimes incorrectly fitted to the wearing surfaces and is not retained in a manner which is deemed acceptable.
 - e Underframe
 - i Equipment retention appears robust and sound.
 - ii Rigid or fixed cable and pipework installations are generally neat and soundly executed.
 - iii Cabling and pipework connections, terminations and routings when moving from the underframe to the equipment are often poorly executed. Wearing and subsequent damage may occur.
 - f Interiors
 - i Broadly functional but tend to be indifferent overall.
 - ii Numerous ceiling and roof panels cracked.
 - iii Trims and finishing pieces loose or incorrectly fitted which could be rectified with little effort.
 - iv Misaligning panels, inconsistent panel gaps, misaligning mounting holes (some elongated to enable fitment) and flimsy roofing panels diminish the overall quality of the interiors.
 - v Internal vehicle end door sensors accessible to passengers may encourage tampering with the sensitivity of the door operation. Suitable prevention could be employed.
 - vi Wear and excessive abrasion to localised areas of the vehicle end doors.
 - vii It is likely that a number of out of use locking features on the gangway doors will not properly function. (see Section 10.4.6)
 - viii The interior may be excited by natural frequencies during service which could give rise to nuisance noises that are deemed to be unacceptable to the passengers. Ride testing would confirm or dispel this hypothesis.
 - g Detailed Design, Quality & Workmanship
 - i It is not possible to open the internal inspection covers situated above the external passenger doors.
 - h Deterioration, wear & corrosion
 - i Fairly advanced corrosion and deterioration was found on localised areas and components which should not be the case considering total distances travelled by the trainsets and the age of the rolling stock.
23. The visual inspections confirm, beyond reasonable doubt, that the V250 trainsets currently have a sufficient number of wide-spread issues where intervention is required by AnsaldoBreda to bring the V250 fleet to a level expected from a competent and reasonable rolling stock manufacturer.
24. Although few areas have been found which warrant immediate safety related action, the use of the V250 trainsets in passenger service will require an on-going inspection and replacement regime at a very frequent periodicity which would likely be too labour intensive to be deemed sustainable and

reasonable for the maintainer to continue with (to achieve the expected performance and reliability from the trainsets).

- 25 Mott MacDonald considers that it is entirely feasible for AnsaldoBreda to develop, plan and execute a suitable remedial plan based upon a number of the conclusions in points 22.a to 22.h above. Subject to availability and utilisation it is considered feasible that such a remedial plan is conducted in situ, at Watergraafsmeer Depot, which would remove the requirement to return the trainsets to the manufacturer which could be costly and detract from the efforts and funds made available towards the remedial plan.
- 26 The potential build quality non-compliances to the specification identified are not considered to be fundamental but at a secondary level.

11.7 Summary

Based on the system reviews undertaken, it is Mott MacDonald's conclusion that the sets substantially meet the specification as agreed between the Awarding Authority and the Manufacturer. There are some non-compliances that were either accepted by the Awarding Authority for initial service or, are secondary in nature. Where the specification has required some interpretation then the train design appears to be compliant with that agreed between the Awarding Authority and AnsaldoBreda. There are some aspects where Mott MacDonald disagrees with the interpretation and some cases where the proposed solution is not, in Mott MacDonald's opinion, adequate.

The manufacturing quality of the trains as seen in Watergraafsmeer is poor in many places. The quality varies between trainsets with the same area being well finished on one set and poorly on another. Audit shows, however, that the paperwork associated with the final build quality is complete and of good quality. How this disconnect has occurred is not understood and its investigation is outside the scope of this study. It is possible that the system driven inspection regime and poor production paperwork may have contributed to this.

Further running is needed at Baseline 10 to prove the baseline and to generate better collated data that can be used to address remaining technical issues. The life cycle cost model also needs further verification although it is accepted that contractually this is supposed to take place five months after the start of service and that NedTrain have started this process.

It is Mott MacDonald's opinion that all the issues that are raised in this report can, through a properly structured, planned and monitored retrofit programme and with further significant test running, be rectified.