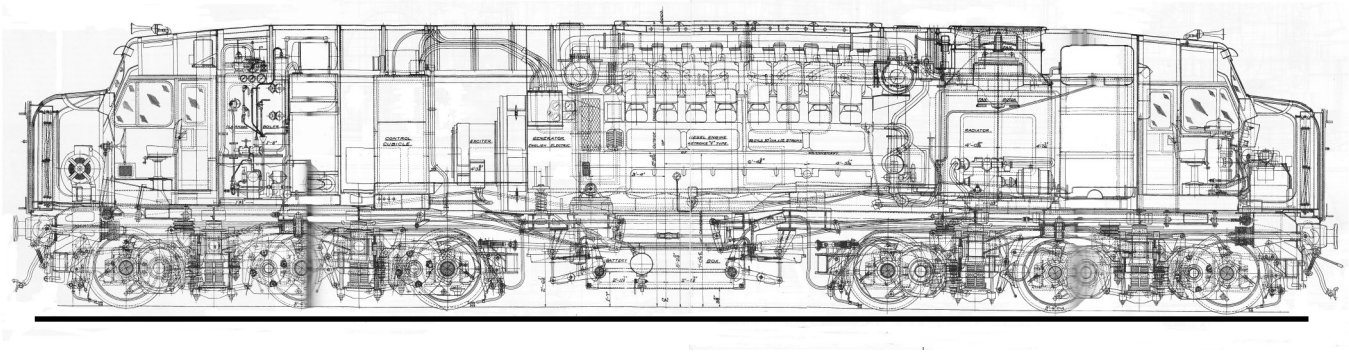
Red Diamond
Diesel Construction

LMS 10000

Class D16/1a Engineering and design overview



D16/1a - major equipment

Chassis
Type: British Rail Class 58
Date of manufacture: 1984
Date obtained: 2016

Rectifier
Type: Class 56
Date of manufacture: 1976-84
Date to be obtained: 2020

Power unit
Type: English Electric 16SVT 1600hp
Date of manufacture: 1947
Date obtained: 2012

Bogies
Type: BR Gorton to a LMS Derby design
Date of manufacture: 1953/54
Date obtained: 2018

Alternators
Types: Brush BA1101A and BAA602A
Date of manufacture: 1976-84
Date to be obtained: 2020

Traction motors
Type: Six 415hp Metro-Vickers MV146
Date of manufacture: 1953/54
Date obtained: 2018/9

CLASS D16/1A

Type 3	Co-Co
Design:	LMSR(1947) / RDDC (2019)
Engine:	English Electric 16SVT mk1
Total b.h.p:	1600hp at 750rpm
Max tractive effort:	184kN (41,400 lb)
Main alternator:	Brush BA1101A
Transmission:	Electric. Six axle hung Metropolitan Vickers MV146 traction motors.
Braking:	Davies and Metcalfe E70 brake system. Vacuum & air
Train heating:	Electric & steam

INTRODUCTION

This document is intended to give an overview of the planned design of our loco, the third Class 16/1 loco, which will be known as LMS 10000.

The roots of the 10000 project go back to 2012, when the group successfully purchased a 1947 build low hours Mark 1 16SVT engine, virtually identical to the one originally fitted to 10000. This was followed in 2016 by the purchase of the donor loco, 58022, which will donate its chassis, along with parts of the electrical and brake system, to the finished project. The last of the major parts of the loco were purchased in 2019, when we acquired a set of original EM2 bogies, almost identical to those fitted to 10000.

10000's launch day in 1947 ©CJM Collection, Courtesy of Modern Locomotives Illustrated Magazine

The external observer would be forgiven for thinking that not much happened in the intervening years, but this is not the case. A huge number of hours were spent preparing designs for the required chassis modifications, identifying what parts were still available and what would need to be manufactured from new, and working out how all those parts would work together. Many hours were spent in the archive of the National Railway Museum, searching out the original drawings for 10000, most of which still exist. Fundraising has been carried out, great efforts have been made to raise the profile of the group, and many other components, and, vitally, spare parts, have been sourced.

In 2019 we also took up residence in our refurbished storage and workshop facility based at Wirksworth on the Ecclesbourne Valley Railway. We are also very pleased to have had a Mk 3 sleeper coach donated to our group by Porterbrook Leasing, making life a lot easier for volunteers living long distances from Derbyshire.

During 2019 we were very pleased to receive a lot of input, assistance and guidance from several recognised industry experts, especially relating to traction equipment, chassis and brake design. It is pleasing that this input has not only given credence to the original IDRS proposal /design but has removed much of the uncertainty surrounding suitable equipment choices. The path forward has now been mapped out to enable us to gain certification for 10000 to haul tourist trains on Heritage railways and beyond, if funding becomes available to do so.

The recreated 10000 will utilise equipment that is available, proven and is adequate for the locomotive to operate beyond its proposed sphere of operation. Due to the complexities and cost involved in exactly replicating the original electrical, brake and cooling systems, we have been advised to utilise Brush power equipment, as fitted to class 56 and 58 diesel locomotives. Not only is this equipment more than up to the job, it greatly simplifies the fitting out process, and minimises the amount of rewiring of the loco that will be required. The use of this equipment has the added bonus of reliability, as the power equipment we will be using is rated well above the 2000bhp maximum theoretical crankshaft output of our 16SVT engine.

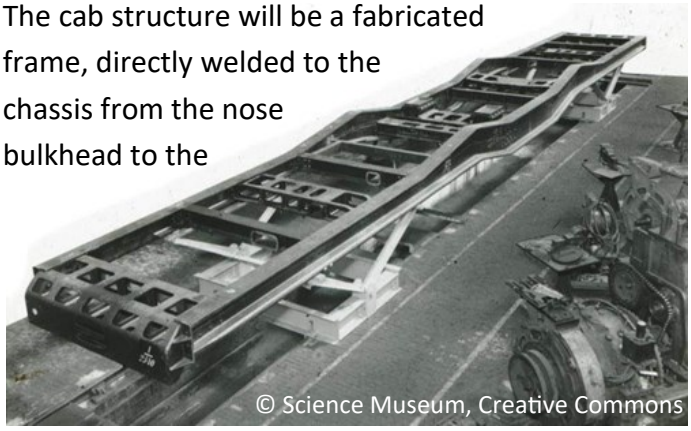
The following sections give an overview of the key components of the build, and the research that has been carried out to ensure those components will work together. It also explains what modifications will be made to these components.

CHASSIS

The Class 58 chassis is very similar in design to Ivatt's original design for 10000, although considerably more robust and with the benefit of a proven track record on Network Rail. The chassis will be modified to provide a greater degree of structural strength, but also increase its weight.

The primary modifications that will be made to the chassis are the inclusion of cross stretchers to accept EM2 type bogie pivots and transfer the weight of the body onto the bogies via traditional bogie bolster pads to the EM2 design. The chassis height will be higher than it was on 10000, as the class 58 chassis height will be maintained. This will create additional space between the bogies and the chassis, which removes the need for a cab floor that is higher than the chassis itself, thereby saving weight.

The cab structure will be a fabricated frame, directly welded to the chassis from the nose bulkhead to the



engine room bulkhead. The cab nose structure has been designed to deform and absorb energy in a crash scenario. It is also designed to minimise potential chassis override as far as reasonably practicable.

It has been possible to include these improvements to the original design without altering the aesthetic appearance of the original in any way; indeed it has made it possible for us to simplify our cab construction method.

The cab and bulkheads provide support to the body structure between them, much as in the original loco. This structure will be of lightweight construction that will carry no additional weight other than its own structure. All internal components will be fitted to the chassis. This will overcome the issue of constant flexing during operation that is a feature of all chassis based locomotive designs.

Utilising the proven class 58 chassis also increases the stability of the loco over the original design. The higher level of the 58 chassis compared to the original means that the crankshaft height of the 16SVT power unit will be lower to the rail height, as the engine will sit between the chassis longitudinal beams rather than above them, as in Ivatt's original design.

LMS 10000 is intended for heritage use only and will not be operating on timetabled passenger/ freight workings on a daily basis. However, during the detailed evaluation of the chassis design, the latest European standards for railway locomotives have been researched, and the criteria set out by the latest crashworthiness standards have been implemented, as far as reasonably practical.

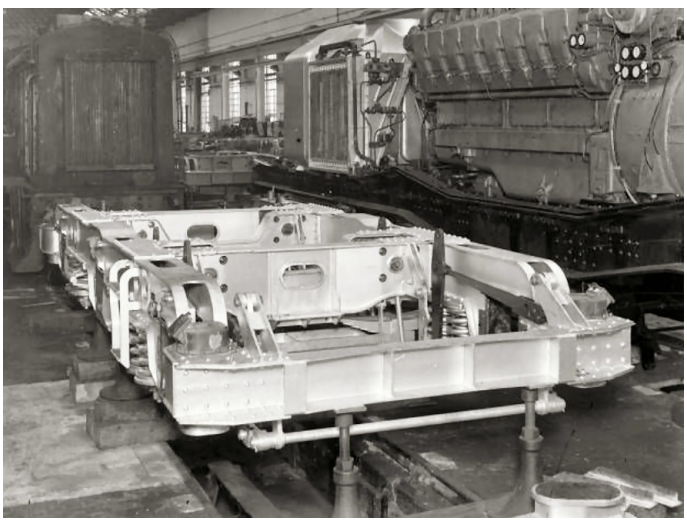
The majority of the original superstructure fabrication drawings exist, and many are already in our possession. We have managed to identify and include some improvements to the original while not detracting from the original design. It is important to us to create the superstructure of the loco to be as aesthetically accurate to the originals as possible, while incorporating the improvements identified.

BOGIES AND TRACTION MOTORS

A set of original EM2 bogies, built in 1951, have been purchased for use on 10000, as they are virtually identical to the original D16/1 bogies. The bogies have been stored outdoors for a number of years and will require a complete overhaul. The bogies and traction motors will be completely stripped and assessed before being shot blasted and painted. Although no fractures have been found or are expected, both bogies will also undergo crack detection during the cleaning and painting process. Appropriate cosmetic alterations will be made to ensure the bogies are a close visual match to the originals.

The refurbishment of the bogies and the decision as to which motors and wheelsets should be used has been the subject of much discussion. After consultation with various industry experts, the most appropriate solution has now been identified.

Our original proposal was to re-engineer the bogies with traction motors of English Electric lineage; the EE538 as used in Class 37. However to fit these motors to the EM2 wheelsets would require them to be fully stripped and re-machined. This carried the risk of rendering one or more axles as scrap if a wheelpan “picked up” upon removal - an entirely possible scenario with interference fits as tight as 7 thousands of an inch. This proposal would also have been extremely costly to carry out. What it would also do is change the proven EM2 bogie design, which would bring an additional set of problems.

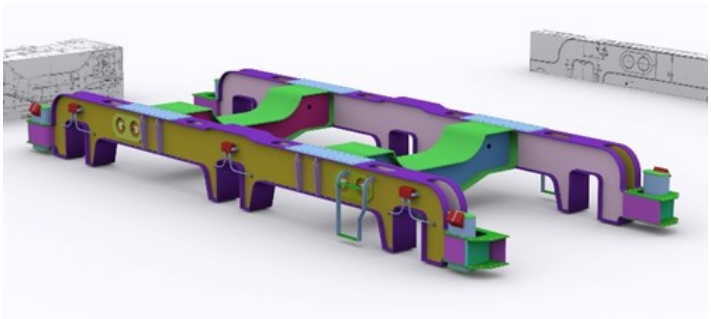


The EM2 bogies purchased are fitted with Metropolitan Vickers MV146 motors, which are similar in design to the EE 519/1B traction motors originally fitted to 10000 but more powerful. It was found that these motors would be suitable and would be able to be connected to the Brush electrical package without difficulty. With this course of action now decided, we have secured budget estimates for the assessment and repair of the Metropolitan Vickers motors. The use of these motors will allow us to utilise all the existing associated parts and removes the need to re-engineer and modify a design that is already proven to work well and is and is fit for future use.

One of our main concerns when deciding which type of motor to use was the difficulty in obtaining additional spare / replacement MV146 motors should one of those in the EM2 bogies suffer a catastrophic failure.

We have been very fortunate in locating some spare MV146 motors in Holland, owned by Werkgroep 1501, who have an EM2 loco in their care. We are very grateful to the group for allowing us to purchase these motors, which have been dry stored, and will need minimal refurbishment before they can be fitted to one of our refurbished bogies. Werkgroep 1501 have also agreed to supply us with several pallets of EM2 bogie and brake spares, which will considerably speed up the bogie refurbishment process.

The bogies will be overhauled and rebuilt to the relevant British Rail Workshop Overhaul Specification Standard that will enable us to achieve mainline registration. This will allow 10000 to access the network dead in tow to enable it to visit locations far and wide.



BRAKING SYSTEM

As part of our evaluation of potential options for wheelsets, motors, bearings and gears, we also looked at how we would stop the loco efficiently. The original locos provided vacuum braking to both the locomotive and train. To replicate the brakes as original would be an expensive and challenging task. It also would render the loco unable to haul air braked stock. We have considered many options, including fitting the class 58 direct acting brake pistons that would minimise the amount of brake rigging that would be required. However, this option brings with it other difficulties, and we have been advised to utilise an already proven method of braking these bogies; the standard EM2 air braking system and its very clever mechanical acting handbrake mechanism.

The use of the EE 16SVT engine will require the removal of the flawed class 58 brake compressors and associated equipment. The removal of this belt driven system takes a lot of unnecessary weight and bulk from the chassis. In its place will be a standard BR Davies and Metcalfe brake compressor as used on classes 43 and 56, and equipment contained within the brake cubicle. The train vacuum braking system will be Westinghouse equipment, as fitted to class 37, similar to the equipment fitted to the original locomotives. This will be controlled from the Davies and Metcalfe electrical controls.

Experience has taught us that the Davies and Metcalfe E70 brake system as fitted in various guises to class 43, 56, 89, 90 and 91 has stood the test of time, being a very reliable and widely accepted system. The decision to use the E70 system on 10000 has been made based on this known reliability, and the currently plentiful supply of spares.

The removal of the original air compressor and associated equipment creates a change to the original class 58 layout. With 10000 being a full width locomotive, we have been able to create additional space to enable us to have full 360 degree access to the brake cubicle. The two main air receivers within the loco will be relocated to the nose ends, freeing up space for the standard air compressors within the brake cubicle, which will allow good access for maintenance. The Westinghouse vacuum exhausters will be located between the cooler group and the cab, in the area made vacant by the reduction in size of the class 58 cooler group. This area is where the fuel tank was located in the original loco. Space has been deliberately left in this area, which gives us flexibility and adaptability during the build process. It would be possible in the future, for example, to utilise this space for additional fuel capacity should the need ever arise.

ENGINE

We have been very lucky in acquiring an original 1947 Mk1 16SVT English Electric engine with very low hours. This engine, vital to the project, is currently in secure storage, protected from the weather.

We are also in contact with the MOD regarding an identical engine which was previously used as a standby power generator. This engine also has very low hours of use. The possession of a spare engine will give us great resilience against any future engine issues that may be encountered.

During inspections of our class 58 loco, it became apparent that the air compressor previously mentioned sits on a heavy frame at the back of the 12 cylinder engine, effectively occupying the place where the rear two pistons of the 16SVT will be. The engine will be mounted in the location where the alternator currently resides. The free end of the engine will have to be mounted on the frame further back, which will necessitate the relocating of the current engine bearer stretcher to align with the rear engine mountings on the 16SVT. It is convenient for our design process that our 16 cylinder non charge cooled engine is actually a similar weight to the 12 cylinder Ruston utilised within the 58, due its large turbocharger, intercoolers, heat exchangers and a very large exhaust silencer.

For our 16SVTs to operate with the Brush electrical equipment our engines will require modified class 56 governors that will be bespoke to our project.
A supplier able to provide this service has been identified and discussions are underway regarding the design.

Some minor adaptations for rail use will be required. The current air start system will be removed, and the injectors will be exchanged for class 20 parts. The fuel pumps may also be required to be exchanged for class 20 items, but this has not yet been confirmed.

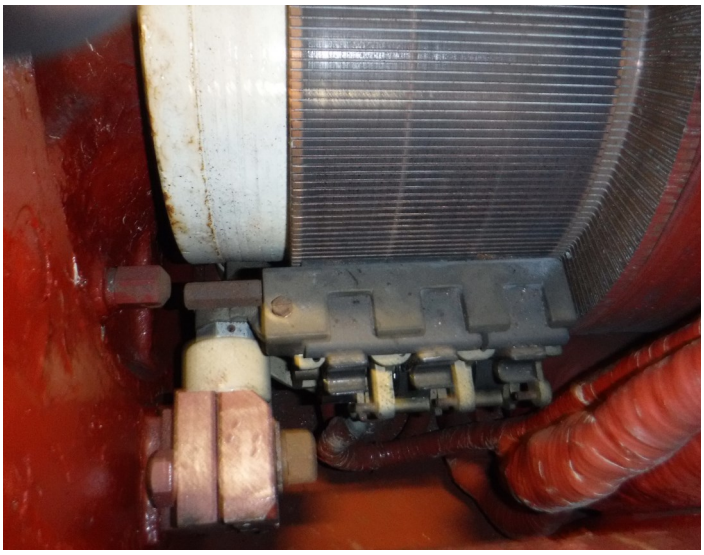
We will require derogation for our 16SVT power plant. The 16SVT has proven itself to be a very clean engine when up to operating temperature and set up correctly, but it has never been Euro 3A compliant and without a great deal of modification it can be reasonably assumed that it never will be. The argument could be made that the 16SVT is more environmentally sound than the equivalent Paxman 16 and 12 cylinder engines used in the class 56 or the 58 and will also use much less fuel.

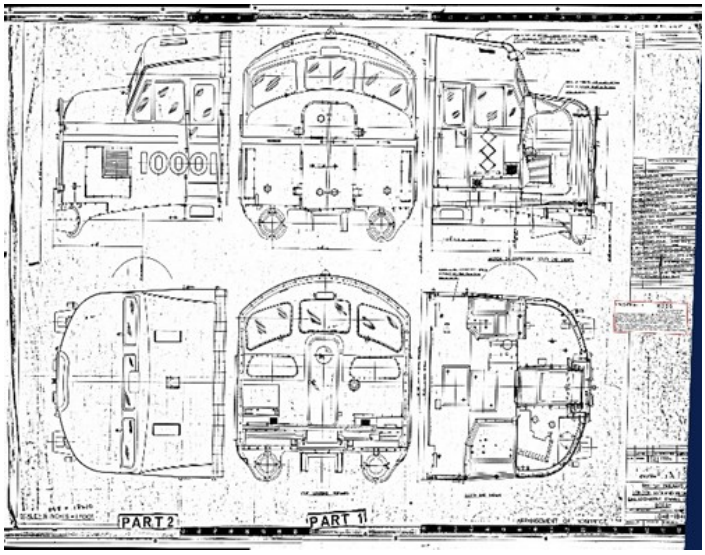
ELECTRICAL EQUIPMENT

The Brush BA1101 alternator utilised on the class 56/58 is of similar dimensions of the EE823A as used in the original. As the original 16SVT and the Paxman fitted to the 56 are basically the same engine, albeit with considerable development and improvement, the fitment of the alternator to the engine will be straight forward.

For convenience, the electrical equipment cubicle will remain in its existing location, although it will contain mainly class 56 equipment, that has minor differences but much better spares availability than the class 58 equipment. Some alterations will be necessary, especially to the various control modules, to give 10000 the maximum potential capability from its much lower maximum engine output. A specialist contractor has been identified who is able to carry out this work. The benefit of 10000 being a full width loco compared to the 58 means that there will be plenty of space around the cubicle, which will give adequate access for development of systems and maintenance.

We are in discussions to obtain a number of ex class 56 items, including two complete electrical cubicles, cooler groups and power units including alternators. This will be a great boost to the project, due to the similarities of the 56 electrical and cooling components to the class 58 we currently own. It will also provide us with a significant source of spare parts, increasing our resilience to any future equipment failures.





Traction Motor blowers and ducting

The traction motor blowers on 10000 and 10001, and several other designs up to the early 1960's, were located in the nose ends, and directed air through a lightweight ducting to each motor position.
The motors were then connected to the duct with a flexible bellow.

The class 58 does not have the benefit of nose ends to house the blowers, and instead both sit close to the engine room; one in the cooler group and one in the auxiliaries compartment. This presents a challenge in that we need to maintain a corridor access through the loco without obstruction, which is not necessary on the class 58 loco. To add to this issue, the traction motors in the EM2 bogies are of a different orientation, meaning that the class 58 ducting ports are in the wrong places for our bogies. Two solutions have been employed to overcome these problems. The blower within the auxiliaries compartment will be rotated by 90 degrees.
The blower in the cooler group remain in its existing location. On examining the existing traction motor ducting outputs, it can be clearly seen that it is possible to remove them and move them to the ideal locations, plating over the holes where they were originally located.

COOLING

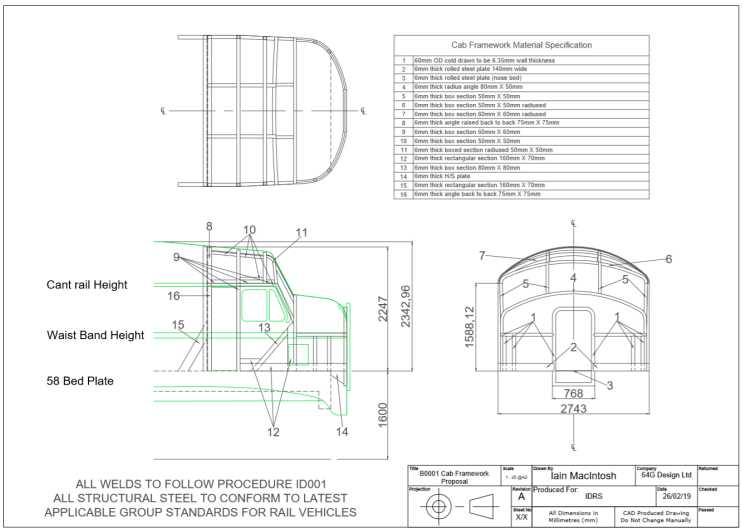
As mentioned above, due to our maximum attainable horse power being significantly lower than the class 58 loco, we will not require its full cooling capacity, and consequently the cooler group will be reduced in size to both reduce weight and replicate more closely the aesthetic appearance of the original Serck radiators fitted to 10000. An issue that affected the original locos throughout their life is that their cooling system was only just up to the job, with the D16/1 locomotives regularly running hot in service. Although it will be reduced in size, the increased capacity of the class 58 cooling system allows us the opportunity to finally resolve this issue.

CAB DESIGN AND EQUIPMENT

We aim to replicate the original cab interior as far as is possible. The design of the cab structure has been completed, and CAD drawings completed of all components. The practicality of the construction has been discussed with steel fabrication contractors, and the construction of the cabs has been fully costed.

The cab will have a steel structure which has been designed in a similar way to the original, but with added structural integrity for protection of the occupants should the worst happen. In addition, all windows will conform to current industry standards. The controls will be tried, tested and certified and calibrated class 56 equipment, disguised to maintain the appearance of the original. The driver's desk and controls will be designed to be easier to remove for maintenance purposes. The cab will function in much the same way as it did in 1947, with access to the nose end doors, air operated wipers, period levers and switches retaining the 1947 image and feel.

Inside the nose end, unlike the original, the loco will not have traction motor blowers, as these are located elsewhere in the class 58, and there is no significant benefit in relocating them. This important and useful area will instead be used for air receivers, the handbrake mechanism and access to the cab control equipment. The nose areas will also contain equipment storage areas with a locker included in each nose.
If mainline running were to become a reality these areas would be the ideal location for the required loco safety systems, and with this in mind the nose ends will be wired to make this possible.



TRAIN HEATING

One of the few significant failings of the D16/1 locos was the train heating system. As built, they were fitted with a Clarkson boiler that was found to be unreliable in service. Our President Stan Fletcher, who was one of the commissioning engineers in 1947 reports that the Clarkson boiler would often shut down during a journey, necessitating repetitive re-lighting with mixed success. The problems were never resolved, and the boiler was replaced with a Spanner Mk1. This increased the locos weight by three imperial tons, and although it was an improvement, the boiler still proved to be problematic and unreliable.

It is our aim to fit 10000 with steam heating; however this is not without its issues. As with steam heating systems of the time, a modern equivalent will weigh several tonnes in fully working order and take up a lot of room within the loco. To fit steam heat may require the relocation of the brake cubical and the electric cubical which will be a complex and expensive task to complete.

It is also planned to fit 10000 with electric train heating, to increase the flexibility of the loco and allow it to operate with more types of stock. The auxiliary alternator that we will be using is capable of far more than the efficient operation of the loco systems, indeed they have been proven to supply an ETH index of 100 on the class 57/3. This equates to around 700hp power consumption which would supply a long air conditioned train. With this type of capacity we do have the ability to fit a system that can heat any heritage railway train, either pulling a rake of mk1 coaching stock or heating a longer rake of mk3 coaching stock with an additional loco for extra traction. As the original loco was not fitter with ETH, the cable will be hidden behind the nose end doors, to maintain the authentic 1947 nose end profile.

It is our aim to make the loco as flexible and useable as possible, to increase the potential for its use, especially throughout the winter season. However, there are some complex issues to overcome, and this is an area that is still under development and review.

A Fulton steam heating unit as fitted to class 31 D5631 on the North Norfolk Railway.

Photo: Anthony Smith

FUEL AND UNDERSLUNG EQUIPMENT

Underneath a class 58 there is a lot of weight suspended between the bogies. All this equipment, including the fuel tank, will be removed.

The air receivers will be relocated to the nose end compartments. The battery boxes will be modified to the dimensions and appearance of the originals. As mentioned earlier, the expected use of the loco will be in a heritage railway setting, and as such the current large fuel capacity will not be a requirement.

A new, significantly smaller fuel tank will be fabricated, that will sit between the battery boxes lowering down towards the centre of the locomotive. This will give 10000 sufficient range and will ensure that we can maintain a clean fuel system by not having too large a fuel system. The tank will be of a robust construction, and manufactured to modern safety standards.

BUILD PROCESS

Utilising the class 58 loco for the chassis of 10000 keeps the loco very close to the basic design of the class 58, which has been used all over Europe and is a fully proven design. However, there will be some modifications required to turn back the clock over 70 years, which will require a “derogation process” to be adopted and examined by Competent Selected Persons.

These modifications will be designed and analysed by Selected Persons to be suitable and sufficient over three criteria; longitudinally, laterally and vertically. Their modification and fitment will be done to an agreed and exacting procedures and standards that are fully documented. All welding will be done by certified and competent persons, and also fully documented to the required quality assurance standards.

Now that our design process for the use of the bogies has been completed, we have effectively created a new locomotive design based on three previous proven designs - Class 58, class 77 (EM2) and 16/1, the original 10000 and 10001. So, we have achieved derogation to an extent already, with the chassis re- design of the bogie pivot method and weight transfer of the loco body onto the bogies.

Our intention to build and maintain the loco to a high level and to a well-documented standard will ensure that the finished loco is fully fit for purpose and is as safe to operate on a rail system both light rail and mainline as any other rail vehicle.

PROJECTED LOCOMOTIVE PERFORMANCE

LMS 10000 has been designed to be a very capable machine. It utilises traction equipment that is capable of much more power than we can feed it with, and retains the reliability of the very lightly stressed engine which was designed to generate 1600hp continually for many hours.

Due to the robust nature of the power equipment it will be possible to make use of the full power of the loco at a low track speed. When put together with the traditional EM2 bogies, the loco will be capable of lifting very heavy trains on steeply graded track without overheating its electrical equipment. The loco will have a theoretical top attainable speed with a 300 tonne train of 80mph with one stage of field weakening taking place at around 45mph. The engine is capable of generating around 1800hp at 750rpm with careful tuning and development. It is however possible to run the power unit safely at 850rpm, which would increase its output to just below type 4 power classification.

In real terms this type of rating with this equipment used will create a diesel electric locomotive very similar in performance and characteristics as a class 57/0 diesel electric. Locomotive tractive effort is expected to be dramatically increased over the original D16/1 design, as is its overall suitability and reliability as a railway vehicle in its own right. However the important factor is, it will operate, look and sound just like it did in 1947.

With railway industry help it has been confirmed that building our locomotive to this design and utilizing the correct method of design and approval is the most fundamentally sound way of recreating 10000. The design decisions that we have made will ensure operational compatibility and spares availability for many years to come. We will have created the ideal locomotive for heritage line use that can be enjoyed by all, while also telling the story of diesel locomotive evolution within the UK.

SUMMARY

To recreate any pre-existing railway vehicle is an expensive and very time consuming undertaking. Due to the historical importance of 10000 and 10001 which undoubtedly set the benchmark in all its design and equipment features to every diesel electric locomotive built since in the UK, the design detailed within this document is the most, accurate, cost effective way to achieve our goal. We have been able to utilise what was learnt over thirty years of loco design it and eradicate most of the shortcomings of the design itself.

As a prototype, the locos were not without their issues and faults. However although they were the first of their kind in the UK, they were very successful, and much was learned over the hundreds of thousands of miles they both operated. We have also managed to eradicate the main shortcomings of the class 58 design. The very problematic air brake compressors will be removed, as will the Ruston engine that BR at one point considered exchanging for a Sulzer 12AS due to the Ruston's poor cold starting, and the habit of pistons and blocks to crack at its original power rating of 3300hp. The bogies that would have been better suited to medium/high speed use instead of slow speed use on poorly laid trackwork that was slippery at the best of times have also gone, exchanged for proven bogies, built to a more traditional design that will be more suitable and sufficient for heritage train use.

In addition to these points, we have saved ourselves a lot of time, effort, money and materials by re-using pre designed and proven brake pipe designs, miles of electrical cables, yards of electrical conduit, approved fire protection systems, and fully proven traction systems.

How ironic it is that the first built British Railways diesel electric locomotive 10001, was to be so similar in design and layout to the last diesel electric locomotive built by British Rail Engineering Limited - 58050. It has been a fascinating process to bring together proven aspects of three locomotives into one design, powered by a very capable and reliable engine. Now that the design decisions have been made comes the most challenging part of the process; turning our design into reality, recreating the legend that was, and will be, LMS 10000.

Alstom courtesy of Staffordshire PastTrack

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