Class 3GT Tinkerbell Technical Specifications

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1.0 INTRODUCTION

1.1 This specification lists the major components and assemblies that will make up the proposed Class 3GT modern high performance miniature 0-4-2T locomotive. Its purpose is to record in one document the most important design features.

1.2 This specification is based on engineering considerations that are not necessarily given here.

1.3 At this stage the specification cannot be definitive, as the optimum form of components and assemblies may only become known as the detail design process evolves. All items listed in this specification are therefore subject to revision at the detail design stage. Where it is apparent that alternative designs have merit, the final choice will be made at the detail design stage, when the alternatives can be considered in depth. These alternatives are given in brackets [ ].

2.0 GENERAL CONSIDERATIONS

2.1 The locomotive shall be faithful to the Stephensonian steam locomotive. The fundamental characteristics shall include:

- A cycle in which the steam, after having worked in the cylinders, is released into the atmosphere
- An exhaust system consisting of static, non-moving parts which keeps the steam-to-air ratio constant over the whole boiler operating range
- A boiler which has good specific evaporation
- A boiler which forms the structural backbone of the locomotive
- A direct connection between the power pistons and the wheels
- A non-enclosed motion
- No recourse to electricity or gears for power transmission
- A rigid wheelbase
- A well-adapted, natural tractive effort curve
- The energy and water supplies are carried with it
- Well-trained, experienced driver necessary

2.2 Four important features will be incorporated:

- Advanced thermodynamics for increased fuel efficiency
- Biomass as a non-polluting, regenerative fuel
- Electronic indicating for accurate performance measurement
- Feed water treatment eliminating corrosion and scale

2.3 The design will include:

- Large streamlined steam passages

- Enlarged steam chest volume
- Minimum clearance volumes
- Elimination of wall effects in the cylinders
- Efficient draught ejector design for lowest possible back pressure combined with maximum possible draught
- Advanced valve and piston tribology
- Gas Producer Combustion System (GPCS) with cyclonic flame path for superior and smokeless combustion
- Economizer
- Feedwater and air heating by exhaust steam
- High thermal efficiency
- Fully insulated boiler and cylinders to reduce heat loss and energy consumption
- Light-weight reciprocating parts
- Low-maintenance and leakage-free sealed rolling element bearings for axles and rods
- Central lubrication
- Ergonomic
- Compliance with environmental protection regulations
- General detail improvements

2.4 The locomotive shall be based on the size and format of the Roger Marsh 'Tinkerbell' 0-4-2T design of 1968, this being a type and size of locomotive most suited to the intended duty of 184/190 mm (7.25/7.5 in) gauge miniature railway service. A characteristic of this type is the marine style boiler with a large firebox for high combustion efficiencies. In order to facilitate certification to run on the Train Mountain infrastructure it shall conform to:

- Maximum axle load of 136 kg (300 lb)
- All overall dimensions constrained by the moving structure gauge

2.5 The locomotive is to be capable of a continuous drawbar power on level tangent track of 2.09 kW (2.8 hp) at 11.2 km/h (7 mph).

2.6 Component design, brake performance, balancing and the stability of the locomotive as a vehicle are to be suitable for a continuous operating speed of 18 km/h (11.25 mph).

2.7 The adhesive weight is to be 272 kg (600 lb).

2.8 The nominal starting tractive effort is to be 0.67 kN (150 lbf).

2.9 To give a large operating range without need to replenish fuel or water supplies (minimum range of 23.5 km (14.6 mi) and 11.3 km (7 mi) respectively under representative average operating conditions) the locomotive is to be designed to carry a total of approximately 24 kg (53 lb) of supplies.

2.10 The design shall meet the requirements of Train Mountain running to the maximum extent possible within the format of a conventional steam locomotive. The extent of conformance with Train Mountain requirements is not covered by this specification, but it is expected to be comprehensive. An exemption shall be sought for any items where non-conformance is unavoidable due to the inherent nature of the design.

3.0 GAS PRODUCER COMBUSTION SYSTEM (GPCS)

3.1 The GPCS consists of a thick firebed which turns it into a gas producer. Only 20% of the combustion air passes as primary air through the grate and biomass, thus leading to almost negligible particle entrainment. The secondary air makes up most of the air needed for combustion and creates an intense turbulence in the flame space so that the gas phase combustion can proceed to the degree of completeness required to meet pollution laws.

3.2 The burner fires vertically up and the flames do not touch the walls, which is important to achieve good combustion and clean emission.

3.3 The use of the GPCS allows biomass to be used in an efficient way and the CO_2 produced by the combustion of the biomass comes from the fixing of CO_2 from the atmosphere. Thus no additional CO_2 is liberated to increase the greenhouse effect.

4.0 ELECTRONIC INDICATING

4.1 Electronic measurement of the indicated power using computer equipment similar to that developed by Professor W. B. Hall shall be used. This makes the precise and continuous monitoring of miniature locomotive performance possible. With an accurate indicator diagram, the amount of work being done is known, and when combined with speed, the amount power produced is known. The accuracy of the motion and valve timing can be easily checked with the computer-generated indicating diagrams.

5.0 MAINFRAME AND ASSOCIATED COMPONENTS

5.1 Welded plate frames shall be used, with the main longitudinals spaced as far apart as possible to allow the maximum width of burner and ash hopper.

5.2 The mainframe longitudinals, particularly between the cylinders and driving axle, shall be well braced laterally by cross-members. The frame braces shall as far as possible be opposite points of maximum loading, and their design and placing shall give maximum lateral stiffness to the complete structure and maximum resistance to the bending effect on the frame of the cylinder steam pressure forces. To minimize frame twist they shall be arranged so that the neutral axis of the complete frame in a vertical plane lies as close as possible to the lines of action of the forces due to steam pressure to which the frame is subjected.

5.3 Very robust and very securely fitted horn stays shall be used.

5.4 The buffer beams, front and rear dragboxes, horn guides, horn stay brackets, spring hanger and equalizer brackets, motion brackets, etc., shall be welded to the mainframe longitudinals were possible.

6.0 BOILER, SUPERHEATER AND SMOKEBOX

6.1 The basis of the boiler design shall satisfy current certification and insurance requirements. Provisionally the boiler shall be of all-steel, all-welded construction except the firetubes which will be copper tubing. The boiler will be built to the Australian Miniature Boiler Safety Committee's 'AMBSC Code Part 2 - Steel Boilers' current standard of construction for the maximum working pressure of 700 kPa (100 psi).

6.1.1 The boiler shall have a marine style firebox.

6.1.2 The front part of the boiler barrel may be arranged as a 'Chapelon type' economizer.

6.2 The boiler shall have a normal working pressure of 675 kPa (98 psi). It shall be designed for and the safety valves set to the maximum working pressure of 700 kPa (100 psi) for ease of keeping the working pressure at 675 kPa (98 psi) without the safety valves lifting.

6.3 The boiler shall be capable of an actual evaporation of not less than 18.9 kg/h (41.7 lb/h) (heat transfer rate of 70,600 kJ/h (66,900 btu/h), giving an equivalent evaporation of 23.6 kg/h (52.1 lb/h)) at an overall efficiency ~80%.

6.4 The boiler will be fired using a Gas Producer Combustion System (GPCS) firebox including restricted primary air, secondary air intake with air preheater, and sealed ashpan.

6.5 The principal overall dimensions of the 'Tinkerbell' boiler and smokebox shall be retained, except that any lengthening of the smokebox necessary to accommodate, for example, the exhaust system, will require a correspondingly shorter boiler barrel.

6.6 The preferred fuel shall be Canola (oilseed rape). The burner and associated equipment is to be 'state of the art' and is required to handle a heat release rate per unit of firebox volume of up to 0.357 GJ/m^3-h (31,500 btu/ft^3-h) with high combustion efficiency. [Alternative - The boiler may be coal fired. This would require the following equipment changes; Coal type Gas Producer Combustion System (GPCS) firebox (restricted-free-air-area firegrate, ashpan, supply of clinker control steam, and secondary air intake with air preheater); coal bunker; means of self-cleaning and spark arresting in the smokebox.]

6.6.1 The burner equipment must prevent any undue concentration of heat flux through any part of the firebox heat transfer surfaces.

6.6.2 The completeness of combustion achieved by the burner equipment should prevent any undue build up of deposits on any boiler, superheater or smokebox surfaces.

6.6.3 The burner equipment shall allow the combustion rate to be readily adjusted to match the steam demand over the boiler's full load range.

6.7 The combustion air is to be preheated by exhaust steam in a heat exchanger, situated immediately upstream of the ashpan, to a temperature of not less than 100 C (212 F). The combustion air intake is to face forward.

6.8 The firebox crown shall be protected against overheating due to low water by fusible plugs.

6.9 The firebox arch, if fitted, shall be of heat resisting steel.

6.10 Both large and small boiler tubes shall have effectively the same length-to-equivalent-diameter ratio.

6.11 Feed water treatment shall be used. This will provide indefinite life for the boiler, superheater and reduced abrasive wear in the cylinders.

6.12 The dry pipe entrance shall be set high up in the dome.

6.13 The valve throttle shall be incorporated into the dry pipe entrance. It shall be connected by internal rodding to a pullout-type throttle lever in the cab. The throttle valve shall be designed to shut automatically in case of broken or uncoupled linkage.

6.14 The superheater shall be designed to give a specific steam temperature at a specific evaporation, for example (but not necessarily) 265 C (509 F) at the maximum rated evaporation, together with minimum steam flow pressure drop.

6.15 The superheater elements shall be of stainless steel tubing, with the addition of welded-on fins if necessary to increase heat transfer. The type of element will depend on the outcome of boiler and superheater fluid flow and heat transfer calculations.

6.15.1 The superheater elements may be welded or bolted to the superheater header.

6.15.2 The superheater header shall have entirely separate saturated and superheated compartments.

6.16 The size and number of the large boiler tubes will be dictated by the superheater design. The greatest number of small boiler tubes allowed by the remaining tubeplate free area will then be used.

6.16.1 The boiler tubes shall be rolled into the tubeplates.

6.17 Three independent boiler feed systems shall be fitted, each with a capacity of not less than the boiler's rated maximum evaporation of 18.9 kg/h (41.7 lb/hr):

- Two live steam injectors and
- An axle-operated, double-acting, reciprocating feedpump, delivering via a tube and shell feedwater heater, situated at the top front of the boiler shell, and giving

a feed temperature of not less than 100 C (212 F) over a wide range of evaporations. Condensate from the feedwater heater is to be piped to the side tank hotwell.

6.18 All boiler feed controls are to be conveniently grouped on the left side of the cab.

6.19 The cylindrical smokebox shell shall be long enough to accommodate all items within it without detrimental compromises in their design.

6.19.1 The smokebox wrapper plate shall be clothed and lightly insulated.

6.19.2 The smokebox door shall be similar to that of 'Tinkerbell', except that it may be arranged to close against a resilient seal to better guarantee air-tightness.

6.19.3 Inspection openings and associated covers may be fitted to the smokebox shell.

6.20 The smokebox shall be bolted or welded to the smokebox saddle. The boiler barrel supports shall be by soft-grease-lubricated bronze sliding pads, and designed to minimize boiler-mainframe heat transfer.

6.21 The smokebox saddle should integrate, if possible, with the cylinder block and shall be of the 'high saddle' type with integral steam pipes from the smokebox to the steamchests.

6.22 The branch steam pipes from the superheater header, which shall be of large cross-sectional area and should be flanged and bolted to the header and steamchests.

6.23 The locomotive shall be fitted with an efficient draught ejector designed for low back pressure. The blast pipe and chimney necessary to give the required exhaust system performance shall be determined by calculation.

6.23.1 The chimney shall be secured by a flat flange to a flat-topped base welded to the smokebox shell.

6.24 The boiler and all external high temperature piping shall be well insulated. The radiation losses become relatively higher at lower power. When the locomotive is standing, the losses are mostly radiation. The insulation shall be as thick as possible, without taking up space necessary for other equipment; up to a maximum thickness of 25 mm (1 in).

6.24.1 The clothing shall be designed to provide adequate support and protection for the insulation and guarantee its long-term effectiveness.

7.0 CYLINDERS AND DRIVING GEAR

7.1 The locomotive shall be of 2-cylinder simple expansion type; with cranks set at 90º, right-hand cranks leading. The proposed design will define 'state of the art' for 2-cylinder simple cycle locomotives running on 184/190 mm (7.25/7.5 in) gauge track, and may serve as a reference level to which the performance of all other locomotive types of this gauge can be compared. [Alternative - The 3-cylinder compound type, with one h. p. and two l. p. cylinders and with the l. p. cranks set at 90º, might offer somewhat better thermal performance, especially at lower speed. An overall thermal improvement sufficient to justify the extra design complexity and higher manufacturing cost cannot be guaranteed.]

7.2 The piston stroke shall be 108 mm (4.25 in) and the cylinder bore diameter 66.5 mm (2.625 in).

7.3 The cylinder blocks, comprised of both cylinder and steam chest, shall preferably be cast as a single piece, or alternatively may be fabricated (welded) or part cast/part fabricated construction. They shall be securely bolted to the mainframe longitudinals.

7.4 Liners of perlitic cast iron shall be fitted to the cylinders. These liners shall be supported in the cylinder bore at the ends only and the annular spaces around the liners shall be filled with insulating material.

7.4.1 The cylinder liners, valve liners and piston and valve rings may be surface treated for wear resistance with the Tufftride processes, hard chromium-plating or thermally-sprayed material.

7.5 The steel front and back cylinder covers shall be bolted on. The covers shall be designed incorporate insulating material. The covers shall be finely machined on the inner surfaces to keep the surfaces contacted by steam at the highest possible temperature and maybe coated with a thermally-sprayed insulating material.

7.5.1 Consideration may be given to the application of an insulating layer, such as thermally-sprayed insulating material, to other non-rubbing cylinder surfaces contacted by steam.

7.6 The Haywood valve gear shall provide large steam-flow areas, yet minimize cylinder clearance volumes (target value not more than 8%) and corresponding heat transfer areas. [Alternative - Consideration may be given to separate inlet and exhaust valves for each cylinder. The inlet operated by Haywood valve gear and the exhaust by eccentric valve gear on each side of the locomotive. The valve gear would be designed to give the required inlet valve events. The exhaust valves would be controlled separately and designed to minimize compression. Inlet valves would be the balanced-slide type. Exhaust valves would be the piston type. The exhaust-valve liners would incorporate steam ports of trapezoidal shape to improve the regularity of boiler combustion air flow.]

7.6.1 The valve gear shall be designed to give optimized valve events. The valve gear shall be as light as possible. The minimum full gear cut-off shall be 75%. The valve gear rods shall be fitted with sealed grease lubricated spherical roller bearings or sealed grease lubricated needle roller bearings. The expansion links shall be of the box design, and the dieblock bearings and dieblock-link rubbing surfaces shall be mechanically lubricated with oil fed via flexible hoses to the radius rods. The reverser shall be the manual screw type.

7.6.2 Valves shall be of balanced slide type.

7.7 The steam chests shall have an internal volume of not less than the piston swept volume.

7.8 The various cylinder steam ports and passages shall be designed for optimum steam flow.

7.9 The cylinders shall be provided with air operated drain valves, controlled by a hand-operated valve in the cab.

7.10 The cylinder block shall be thoroughly insulated, using welded-on clothings to seal the insulation in place wherever possible (no pipe couplings shall be made under any clothings). Exposed surfaces of the smokebox saddle and, if practical, those parts of the mainframes next to the cylinders, shall also be insulated by the same means. [Alternative - Consideration may be given to steam jacketing the cylinders and steam chests.]

7.11 No snifting or by-pass valves shall be fitted.

7.11.1 Drifting shall be in mid-gear with a very small amount of drifting steam supplied by putting the throttle lever against the drifting stop.

7.12 All reciprocating components shall be carefully designed for minimum mass.

7.13 Lightweight pistons having a fine surface-finish and each carrying 2 rings shall be used.

7.14 Piston rings, valve seats and piston rod and valve-spindle packing shall be designed to minimize steam leakage as a fraction of maximum boiler evaporation.

7.15 The crossheads shall be of the lightest possible design. Each crosshead, which may be of aluminum alloy, shall slide on a 1-bar type slidebar. The gudgeon pins shall be fitted with roller bearings, which may be either in the crosshead or in the connecting rod.

7.16 The connecting rods may be of either lightweight I or rectangular section in steel or light alloy with a spherical roller bearing at the crankpin end.

7.17 The coupling rods may be of either lightweight I or rectangular section and shall be fitted either with a spherical roller bearing at each crankpin or, at the leading crankpins only, with a cylindrical roller bearing at the main crankpin.

7.18 The connecting and coupling rod roller bearings shall be grease lubricated.

7.19 The driving and coupled wheel centers shall be solid.

7.19.1 The tire profile shall be of Train Mountain 184/190 mm (7.25/7.5 in) narrow gauge type.

7.20 The rotating masses on each wheel shall be precisely dynamically-balanced on the same wheel. A percentage of the reciprocating masses on each side of the locomotive are to be balanced, which percentage is to be the minimum at which the out-of-balance forces at the maximum continuous operating speed give rise to accelerations of the locomotive's structure which do not exceed proscribed values. The total reciprocating balance is to be shared amongst all the driving and coupled wheels. The aim shall be that the individual wheel, individual axle, and total dynamic augments at the locomotive's maximum permitted speed of 18 km/h (11.25 mph) shall not exceed 17 kg (37.5 lb).

7.21 The driving and coupled axles, which may be hollow, shall run in sealed grease-lubricated, spherical-roller-bearings mounted in one-piece or split axleboxes.

7.22 The driving and coupled wheel axleboxes shall be provided with wedges. The driving axlebox shall have parallel guides at the rear and spring loaded wedges at the front and the coupled axlebox shall have fixed wedges at the rear and spring loaded wedges at the front. The position of the fixed wedges shall accord with the exact coupling rod lengths between bearing centers, and shall be lockable. The spring loading of the wedges shall be of the single spring type.

7.22.1 Where appropriate, rubbing surfaces of the axleboxes and their guides/wedges shall be fitted with wear-resistant, non-metallic 'dry' materials.

7.23 The driving and coupled axle springs on each side of the locomotive shall be compensated, giving, together with the trailing bogie, 3-point suspension of the sprung masses of the locomotive as a whole.

8.0 TRAILING BOGIE

8.1 The trailing bogie frame shall be of fabricated (welded) steel.

8.2 The maximum lateral displacement of the trailing bogie shall not be less than that required to negotiate a 15.25 m (50 ft) radius.

8.3 Spring centering shall be used, the centering force-to-displacement relationship being arranged to give maximum stability during running together with ease of negotiating small-radius curves.

8.4 Inside axle bearings shall be used. The trailing bogie wheelset shall run in sealed grease-lubricated, spherical-roller-bearings mounted in one-piece axleboxes.

8.5 The trailing bogie wheels shall be of solid-disc type.

8.6 Weight transfer shall be via coil springs in the center of the trailing bogie to distribute the load equally to the two wheels.

8.7 The locomotive's speedometer shall be driven from the trailing bogie axle.

9.0 BRAKE GEAR

9.1 The locomotive itself shall be fitted with Hayes Brake 400M mechanical disc brakes and shall be equipped to work air-braked stock and, only if necessary, vacuum-braked stock. Brake operation and performance shall satisfy Train Mountain requirements at all speeds up-to-and-including the locomotive's maximum permitted speed.

9.2 A reciprocating, electrically-driven air compressor of adequate capacity shall be fitted for supplying compressed air for train braking and air-operated auxiliaries such as sanding.

9.3 Disc brakes shall be fitted to all axles. The line of action of disk brake forces should provide anti-dive.

9.4 The maximum braking force on the locomotive, as a percentage of the total fully loaded locomotive weight, shall be 75%.

9.5 For slip control there shall be an independent foot-pedal-controlled, anti-slip-brake acting on the driving wheels only. This may also function as a low-speed, independent, locomotive brake.

9.6 The brakes shall be arranged so that full sanding is automatically applied during an emergency brake application.

9.7 The parking brake shall act on the trailing bogie axle only and shall be spring-applied and air-released.

10.0 SANDING GEAR

10.1 The leading coupled-wheels shall be sanded for forward and reverse running. All sand nozzles shall be bracketed from the axleboxes for optimum alignment. The sandbox shall be centrally located. Glass beads will be used as the sanding medium. A foot pedal shall operate the air sanding.

10.2 A rail washer, using boiler water, may be fitted to clear sand from the rails behind the trailing coupled-wheels during normal (non-emergency brake) sanding.

11.0 LUBRICATION EQUIPMENT

11.1 It is intended that the locomotive shall require lubricating only by servicing staff and that the locomotive driver shall have no lubrication duties.

11.2 Cylinder oil shall be used for pistons, valves, piston and valve rods and slidebars. Cylinder oil is to be fed to all these parts by a single mechanical lubricator supplied by an approximately 250 ml (0.5 pt) capacity oil reservoir mounted on one running board. This lubricator may be driven from a point in the valve gear such that the oil feeds are proportional to locomotive cut-off. The valve oil feeds are to be direct to the valve rubbing surfaces.

11.3 Machine oil with EP capability shall be used for all other oil-lubricated components, which may include expansion link dieblocks. Machine oil is to be fed to all such parts by a single mechanical lubricator supplied by an approximately 250 ml (0.5 pt) capacity oil reservoir mounted on one running board. [Alternative - Consideration shall be given to using cylinder oil throughout, in which case only a single mechanical lubricator and associated oil tank may be necessary.]

11.4 Roller bearing grease is to be used for all roller bearings.

11.5 Soft grease is to be used for all rubbing surfaces not fitted with 'dry' materials that see little movement, such as the boiler expansion slides. It shall also be used for any valve gear pin-joints not fitted with roller bearings.

11.6 For mechanically lubricated items, an appropriate oil check valve is to be placed in the oil pipe as close as possible to the item concerned, and drip trays shall be fitted where necessary and possible, to prevent spent oil contaminating the tires and rails.

12.0 CAB

12.1 The cab shall comply with the safety features required by Train Mountain.

12.2 Cab fittings shall, as far as possible, be of readily-available, proprietary type.

12.3 Windows providing good visibility shall be provided at the front of the cab.

12.4 The cab shall be faithful to the 'Tinkerbell' design.

12.5 The cab shall be provided with an ergonomically-designed-and-located seat for the driver.

12.6 The controls for the driver shall be ergonomically arranged to be within convenient reach from a sitting position.

12.7 Foot pedal controls shall be provided for the anti-slip brake and sanding.

12.8 The throttle lever shall be lockable at the full open and shut positions only, and with a stop locating the drifting position.

12.9 The boiler gauge glasses shall be of the type most suited to the boiler's authorized maximum working pressure. Their steam and water connections shall be provided with extension tubes of suitable length inside the boiler, to avoid false water level readings.

12.10 Exhaust back pressure, smokebox vacuum and secondary air vacuum gauges shall be provided and mounted on the cab front bulkhead.

13.0 ELECTRICAL EQUIPMENT

13.1 A 12 volt DC battery electrical system shall be fitted and be of sufficient capacity to power all electrical equipment on the locomotive. A 115/230 volt AC powered charging system for the battery shall be included.

13.2 Lights for both directions of running shall be fitted which comply with the relevant Train Mountain requirements.

13.3 Suitable cab lighting shall be fitted, including an illumination of all gauges, that does not detract from the driver's vision ahead.

13.4 Other electrical equipment shall be fitted as required.

14.0 SIDE TANKS

14.1 Side tanks with large fuel and water capacities are necessary to allow for the absence of replenishing facilities. The capacities shall be at least 5.1 kg (11.2 lb) of Canola (oilseed rape) and 18.9 kg (41.7 lb) of water, giving operating range under representative, average, Train Mountain main-line operating conditions of approximately 23.5 km (14.6 mi) and 11.3 km (7 mi) respectively.

14.2 The side tank design shall maximize quantity of supplies that can be carried.

14.3 The side tanks may be extended down between the frames to form a hot well for maximum heat recovery from condensate returned to the tank.

14.4 Effective dispensing apparatus for boiler water treatment chemicals shall be fitted in one of the water tanks.

14.5 Accurate fuel and water gauges shall be fitted on the cab front bulkhead.

14.6 A water-filling point for on-shed filling shall be sited at a convenient position and shall have a coupling compatible with a standard water hose. The water gauge shall be duplicated at the filling point.

14.6.1 A water filler-hole shall be provided in the top front of each tank.

15.0 DRAWGEAR

15.1 The locomotive drawgear shall be compatible with Train Mountain standard stock.

15.2 The drawgear shall incorporate features that effectively reduce the fore-and-aft accelerations due to the unbalanced reciprocating masses.

16.0 EXTERNAL APPEARANCE

16.1 The locomotive shall have an outline faithful to Marsh's the original 'Tinkerbell'. It shall be painted Gloss Buffer Beam Red in honor of L. D. Porta.

17.0 MISCELLANEOUS

17.1 All safety appliances and markings shall conform to current Train Mountain regulations.

17.2 A chime whistle shall be fitted.

17.3 A connection for compressed air to power the blower during steam raising shall be fitted.

17.4 Pipe work shall be sited and supported so as to ensure accessibility and rigidity, and to minimize vibration, looseness and leaking joints. No pipe connection (water, steam or oil) shall lie over the coupled wheels or rails.

Appendix I - Photographs

Below are five pictures of the original Roger Marsh 'Tinkerbell' at the Moors Valley Railway taken by Phil Copleston© in 2003.

Appendix II - Calculations	
Tractive Effort	
$T = D^2 SP / W$ were T is tractive force (lb) D is diameter of piston (in) S is stroke (in) P is mean effective pressure (psi) W is diameter of wheel (in)	$T = 2.625^2 * 4.25 * 80 / 9.75$ $T = 240.29$ T is 240.29 lb D is 2.625 in S is 4.25 in P is 80 psi W is 9.75 in
How Much Steam at 7 mph?	
7 mph is 36,960 ft/hr	$7 * 5{,}280 = 36{,}960$
one wheel revolution is 2.553 ft	$9.75\pi / 12 = 2.553$
revolutions per hour is 14,477 rev/hr	$36{,}960 / 2.553 = 14{,}477.086$
piston area is 5.412 in^2	$\pi(2.625/2)^2 = 5.412$
steam volume is 23.001 in^3 at 25% emission	$5.41 * 4.25 * 0.25 * 4 = 23.001$
steam volume is 0.013 ft^3 at 25% emission	$23.001 / 12^3 = 0.013$
steam volume for 1 hour at 7 mph is 188.202 ft^3	$0.013 * 14477.086 = 188.202$
steam volume at 1.25 quality is 235.379 ft^3	$188.303 * 1.25 = 235.379$
density at 100 psi sat + 100C is 0.1771 lb/ft^3	---
weight of steam per hour at 7 mph is 41.686 lb	$235.379 * 0.1771 = 41.686$
heat required 70F to 509F is 1283.8967 btu/lb hr	---
heat required is 53,520.031 btu/hr	$41.686 * 1283.8967 = 53{,}520.031$
input at 80% efficiency is 66,900.039 btu/hr	$53{,}520.031 / 0.8 = 66{,}900.039$
volume of water is 5.004 gal/hr	$41.686 / 8.33 = 5.004$
weight of water is 41.683 lb/hr	$5.004 * 8.33 = 41.683$
weight of canola (oilseed rape) is 5.352 lb/hr	$66{,}900.039 / 12{,}500 = 5.352$
drawbar power is 2.804 hp	$0.00267 * 150 * 7.0 = 2.804$