FREMO87
Module Standards
Standard Gauge 1,435 mm

MMVI

Inhalt

Initially compiled:	12th of November 2002
Translate and last up-date:	30 July 2006
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1 Introduction

These standards for the FREMO87-Modules were compiled to ensure that all modules and vehicles that are being built in accordance to these standards could be interconnected mechanically and electrically thus enabling their – more or less - arbitrary arrangement into big module arrangements.

The standards take into account the standards as were initially compiled by Udo Böhnlein for H0pur® [1]-arrangements i. e. the modules built to these standards can easily be integrated into a FREMO87-module arrangement. A separate standard takes care of the narrow gauge prototypes of 1,000mm, 750 mm and 600 mm.

The present standards have been subdivided into topics that have been classified into commitments and explanations thereof. Commitments are binding. If required a column is added that makes a reference to an explanatory figure.

Moreover a chapter was added that contents no standards but just recommendations. Here you'll find things that have been proven practically in the FREMO-history and the observance of which would be advantageous. On the other hand different solutions will be available that also come out with good results; moreover these recommendations are not absolutely required for a flawless operation and fitting together of modules.

A separate modelling handbook will also in short time be available in an English translation. Some more work should be done in this field to ensure a more uniform look of all modules from the different sources. Nonetheless there may be differences due to the chosen prototype as e. g. of the ballast, the prevailing architecture or the vegetation.

For general reference to FREMO-meetings, for the operation or for DCC please refer to www.fremo-87.de or to the homepage of FREMO under www.fremo.org. Please be reminded that the general discussion language is German but all mails in English will be answered.

While taking a first look these standards may appear like a rigid and confining corset. When giving it a closer look one will realise that most topics are to a certain extent self-evident but have just been written down. There will always be enough openness for the module railroader to follow his individual ideas. Moreover these standards never claim to be complete or final thus always enabling further improvements or up-dates that lie within the general interest of all active module builders.

The main objective for all who become involved with the building and operation within FREMO should be to always apply the best standard and technology available. In this instance that means that as far as technically possible prototypical and close to scale tracks, motive power, landscaping, operation etc. should be tried to achieve. This goal may not easily be reached but it should always guide the modeller into the right direction.

What is obvious is that for a smooth and flawless operation in combination with close to scale wheel and rail standards much higher precision is asked for than in "ordinary" modular railroading:

- At present all the tracks have to be scratch build, no RTR-tracks or switches are available to date.
- There will be no motive power or wagons that can be taken out of the box for operation. Time-consuming and costly modifications will always have to be made. Wagons - apart from adding details and painting – have to be provided with a 3-point suspension respectively springing.
- The surroundings have to be matched to the highly detailed tracks and motive power and wagons. Also here a lot of scratch building is being asked for.

Who now is still not scared away by the lot of work involved may read on and may absorb the following commitments and explanations. One is rewarded with a optical pleasing and reliable to operate system –despite the small flanges.

Please note that the described standards are close to but NOT identical to Proto87-dimensions.

[1] H0pur® is a Trademark of Willy Kosak Verlagsges. mbH.

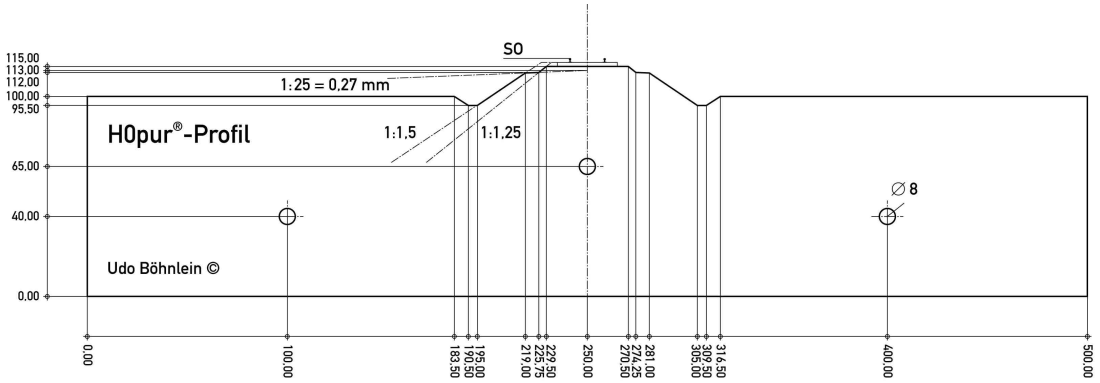
2 Theme / Period

	Commitment:	Explanation:
2.1	Theme is a standard gauge branch line or short line	*The theme will be realised as closely as technical feasible and possible in 1:87 scale of the prototype.* *Basically also a 2 track main-line may be possible.*
2.2	Plain, rural countryside and highlands	*Most railways have been built for the development of rural areas.* *Mainly agricultural products were transported (e.g. sugar beet, fertilizer, timber). Moreover it was tried to avoid costly bridges and thus the railways were commonly arranged in the bottom of valleys. Our modules in average represent a prototype width of 45 m. thus a flat module showing no hills is quite often prototypical even for mountainous areas; obviously this doesn't prevent the installation of bridges, hills, tunnels and rivers on modules.*
2.3	Free landscaping	*Every prototypical landscape (or at least credible landscape) and every prototypical installation may be modelled.*
2.4	Period: 1955 to 1970 (Period 3b - 4a)	*During this period most railways still carried out interesting and lots of goods and passenger trains operations. This period is also fairly good documented in the literature. Due to the rubber tired competition the traffic after this period went down quite fast having the result of closing down of numerous branch lines.* *If a short line is modelled it has to be noted that quite frequently used material from the state railways or other private railways was used.* ***As the FREMO originated in Germany/ Central Europe the standards have been developed for a prototype of this area specifically the German Railways (Deutsche Bundesbahn).*** *Principally also modules from other states or periods may be build.*
2.5	Season: Summer	*This can be modelled fairly convincingly; moreover most modellers seem to give preference to this season.*
2.6	Passenger- and goods traffic	*Transportation of goods and handling of goods wagons is the main objective.*
2.7	Steam- and diesel traction	*In the 1950ies it was tried to improve the profitability by introduction of dieselisation but steam locos often were kept in service.*

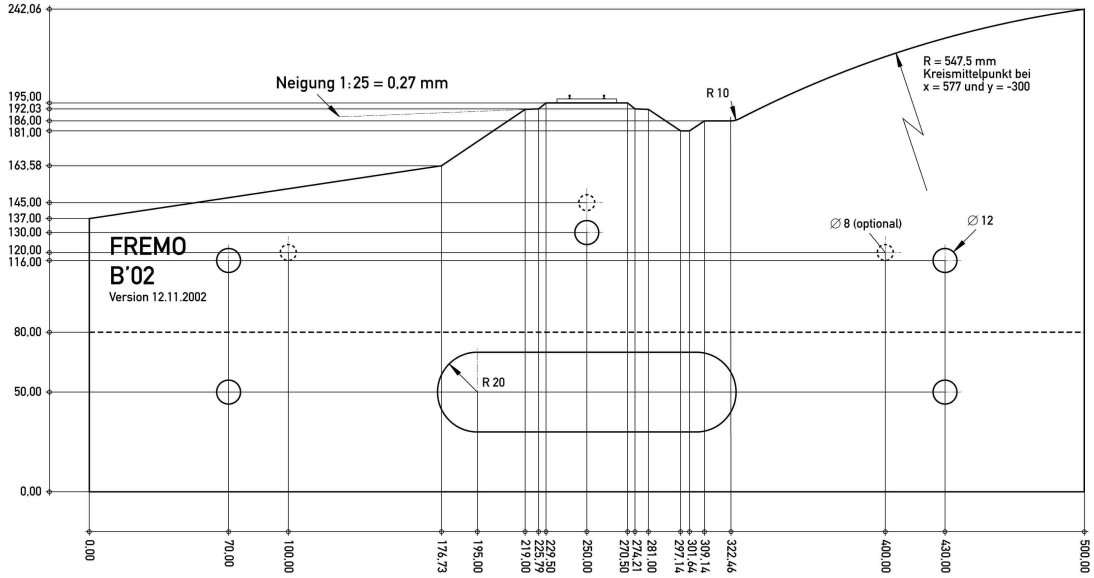
	Commitment:	Explanation:
2.8	NO Catenary	*Catenary on single-track lines was to be found quite seldom. Moreover a highly detailed and/ or functioning catenary (especially when close to scale) is difficult to build – this especially applies also for the transition area between modules.* *Traction and streetcar themes may be interesting due to the small flanges and thus the small channels required in the streets but modules with such prototype are not our theme.*
2.9	Operation following the rules of the "Regeln für den vereinfachten Nebenbahnbetrieb" of 1950	*If no signals are provided in the stations this type of operation may be carried out; alternatively signals may be used. This will be agreed upon before the session starts.* *In case of main-lines the respective reporting-operation has to be carried out.*
2.10	Signal technology following the rules of the "Regeln für den vereinfachten Nebenbahnbetrieb" of 1950	*If no signals are provided in the stations this type of operation may be carried out; alternatively signals may be used. This will be agreed upon before the session starts.*
	Alternatively a signal system may be applied	*In case of main-lines signalling systems are obligatory.*
2.11	Industrial Railways, Private Railways, etc.	*Modules that cover other themes than named above (e. g. turn of the 20th century railways, industries, short lines etc.) can be build and become integrated into a modular layout. Prerequisitive is that they can be matched from style and overall impression into the modular layout.*

3 Module Base Structure

	Commitment:	Fig:	Explanation:
3.1	• End profile compatible to the H0-pur standard recommendation • FREMO B02-profile	**3.1°** **3.1b**	*This ensures that modules that have already been built in accordance to the H0-pur-standard can easily be integrated into module arrangements.* *On the other side standard FREMO - open track modules that meet the high FREMO87-standard may also be integrated into an arrangement (apart from the bolts and plates fastening the rails due to the oversized flanges). Transition modules that have different end on either side are welcome.*

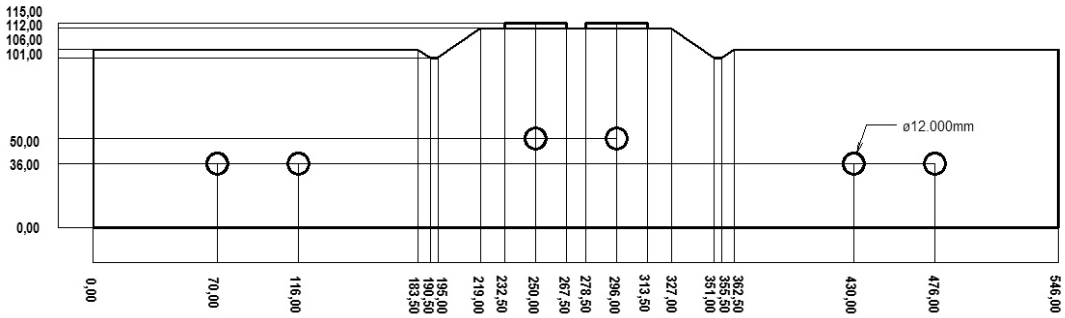


3.1a End profile FREMO87 (compatible to H0pur®)

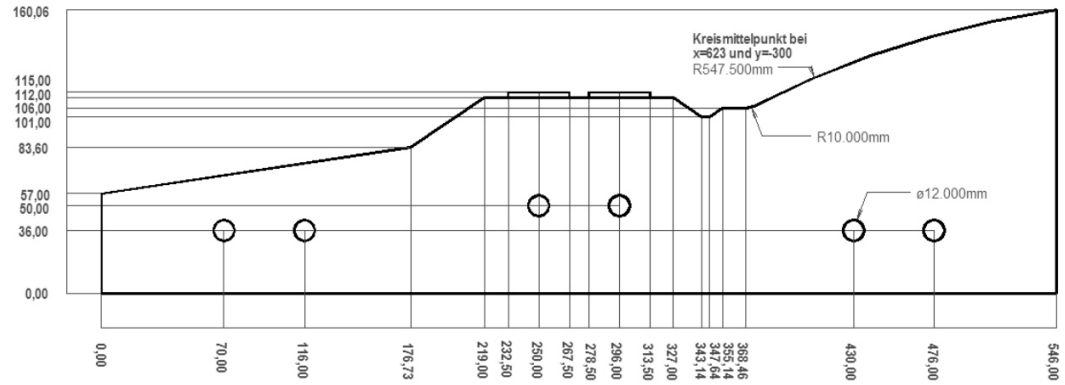


3.1b End profile B02 (B'96 with FREMO87-dam)

	Commitment:	Fig:	Explanation:
3.2	• H0pur – double track • B02 – double track	**3.2a** **3.2b**	*Naturally FREMO87 also allows for double track modules.* *The additional holes ensure that double track modules can be directly connected to the standard single track modules without separate adaptor pieces.*

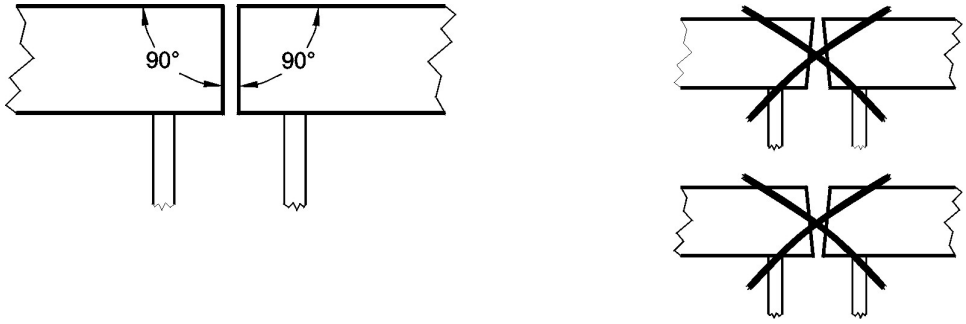


3.2a End profile FREMO87 (compatible to H0pur) – double track



3.2b End profile B02 (B'96 with FREMO87-dam) – double track

	Commitment:	Fig:	Explanation:
3.3	The end of the modules **have to be** absolutely vertical	**3.3**	*Otherwise a non-distorted erection of a whole modular layout would be nearly impossible. Moreover adjacent module may be damaged.* *Recommendation:* *The actual track-base should be led directly to the end of each module thus preventing "ski-jumping platforms" in this place.*



3.3 Module ends (as seen from the side)

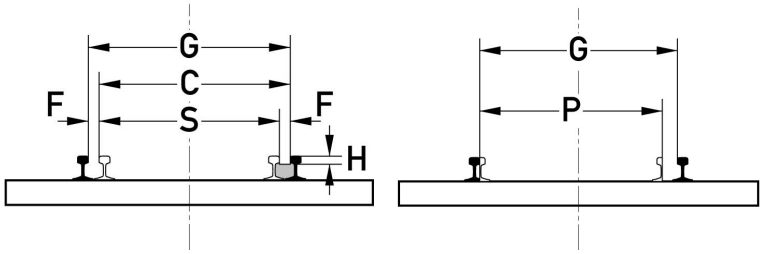
3.4	The track ends rectangular to the end of the end-profile of the module	*Otherwise a bend would result between the modules preventing a safe and smooth operation and probably also causing derailments.*
3.5	Holes for the connection bolts in the shown arrangement with 12 resp. 8 mm diameter	*The arrangement of a hole directly under the centre of the track (this hole also acts as a reference for the other holes) allows for a free choice of the where the rails are being placed.* *One has to note that the connection holes are not obstructed by reinforcements in the module, switchgear etc. so that the connecting bolts (3.5) can be installed without problems.*
3.6	Module connections have to be made with 3 M 8-bolts and 3 M 8 wing-nuts in combination with large washers (so called body-making washers)	*Small inaccuracies may be overcome by applying a smaller bolt in a big hole.* *The big flat washers minimize the damage to the end profiles due to the high pressure of the bolts thus also dissipating the forces. The wings of the wing nuts should not be too small.* *It is recommended to drill the holes in the end profile after the rail installation on the module.*

	Commitment:	Fig:	Explanation:
3.7	Module height 1300 mm above floor		*The height is measured over the top of the rails (**not** the top of the module). It makes sense to provide adjustability in the legs of ± 15 mm.* *A module height of 1,300 mm is a compromise between optic (one doesn't only see the rooftops of the wagons and motive power but can see the models from the side) and operatability (shunting). Moreover this is the standard height of all other FREMO-module groups thus enabling also the direct transfer of standard gauge cars onto boogies or standard gauge transport cars of the narrow gauge.* *Remark:* *The H0e-group has standardised the top of module height to be 1,300 mm.* *Last but not least this height also enables – even for older FREMO-members to duck-under the modules as required in certain arrangements.*
3.8	Module width as well as minimum distance of 100 mm between mid of track and side of module		*The module width of 500 mm the end-profiles as shown in 7.1 should only less in very special applications.* *Especially in stations the minimum distance to the module sides may be less than 250 mm; a minimum distance of 100 mm should **always** be obtained to prevent derailed, overturning vehicles to easily fall to the ground 1,300 mm below.*
3.9	Module height should be as low as static possible		*A low height of the modules makes best use of the – often - limited transport space to module meetings. Moreover it becomes easier to cross under modules on the meetings.*
3.10	The module ends have to be furnished with green grass		*Thus a harmonic appearance of the arrangement should be ensured. The right material can even cover or hide the inevitable gaps between modules to a certain extent.*
3.11	Module structures have to be painted dark-brown (RAL 8017) A different colour may be possible but doesn't support the idea of a uniform appearance of the whole modular layout		*Even though this is contradictory to ecological thinking **no** water-soluble paint should be used. Experience has shown that these paints doesn't harden and dry out easily and may even cause severe damage to module ends when bolted together (when it is tried to pull the modules apart again).*

	Commitment:	Fig:	Explanation:
3.12	Two pairs of legs for each module		*Each module has to stand on it's own legs to enable the free placement and late changes during the erection of a modular layout arrangement. Modules that have to be held in suspension until they are bolted to an adjacent module severely hamper a fluent erection and the optimum using of the available space.* *A proven technology is cut-out-pockets in the underside of the modules in which the legs are just inserted. Adjusting bolts integrated in the lower ends of the legs are an easy adjustment of module height to match with the other modules.* *In case if 300 – 500 mm short modules only one pair of legs may be required.*
3.13	Each module should be marked at the underside with name and address of the module owner, the number and description of the module and possible operational specifics		*The clear marking of modules prevents confusions especially when the actual module owner cannot be present at a meeting. Moreover it makes sense to give a name to a module respectively group of modules (not only to the stations). This eases the unmistakable planning and assignation during planning and erection. Special installations and their operation (e. g. special signalling technology, loading installations transition installations for transferring standard gauge cars to narrow gauge etc.) should be described in short to also enable their operation by other people than the module owner himself. It may be required that a short training has to be carried out on this specific installation before operation on the arrangement can commence.*
3.14	Modules should have a sturdy design and stability and should not be distorted		*One should refer to the numerous articles on module construction that also have been published in the FREMO-HP1.*

4 Rail System

	Commitment:	Fig:	Explanation:
4.1	Dimensions of rails	**4.1**	*The shown dimensions have to be obtained. It is aspired to operate modules and vehicles in accordance to FREMO87 and proto87 standards on one modular layout.*



	Prototype EBO [mm]	1:87 [mm]	FREMO87 (H0pur) [mm]	
Dimension of turnouts				
G	1430 - 1470	16,44 - 16,90	16,50 - 16,60	Track gauge (min)
C	1394	16,00	15,90 – 16,10	Check gauge
S			15,30 – 15,60	Between check faces
F1	41	0,47	0,50 - 0,55	Flangeway (guiding gap)
F2	47 – 70	0,54 – 0,80	0,50 - 0,60	Flangeway (other)
H	38	0,44	0,45	Flange depth
P	1290	14,83	14,80	Point gauge

4.1 Fig. and table track dimensions FREMO87

4.2 Profile of rail

Rails of the S49-profile (49 kg/m) should be aspired. This is closely resembled by the code 70 profile. It has to be noted that apart from the height anything is wrong with this commercially available rails (dimension-wise). Most parts (bolts and parts to hold the rails to the sleepers) on the other hand are designed to be used with this type of rail.

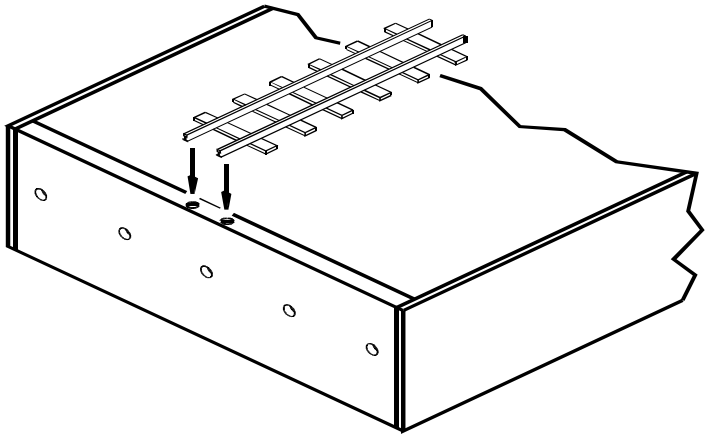
Naturally other profiles may be used if they represent a different prototype.

4.3 Min. radii

The prototypical modification of the vehicles also require the application of prototypical radii. One may only be allowed to deviate from the listed radii in case one models e. g. a prototype of the early 20th century. The main line should on the other hand always have a minimum radius of 2,069 mm to not restrict the free use of all vehicles on the whole layout.

Commitment:	Fig:	Explanation:
190 m = 2.184 mm (1:87)		*Min-. radius for switches and curves in main tracks that can only be remained under in the case e. g. of siding tracks or in other situations as from the prototype.* *Remark: for most steam locos as e.g. the famous 4-6-2 01 this was the min. design radius.*
300 m = 3.448 mm (1:87)		*For curve modules without super elevation V_{max} = 50 km/h, with super elevation V_{max} = 80 km/h. The last figure is also the highest permissible speed on secondary lines. This means that most model railroaders drive much to fast with their models. 80 km/h may not be very fast though but prototypical.* *Min. radius in the main track of double track lines.*
180 m = 2.069 mm (1:87)		*Min. radius in the main track of single-track operations. Please note that in the meantime several locos especially steam locos have been specially adapted to this minimum radius and can no longer negotiate smaller radii.*
80 m = 919 mm (1:87)		*In sidings the min. technically negotiable radius that can be obtained by most vehicles. May still be used in sidings to manufacturing plants etc.*
35 m = 402 mm (1:87)		*This radius was used in very confined spaces. In the prototype these radii cannot be negotiated by wagons with length of more than 4.5 m and all wagons with bogies. The Maschinenfabrik Deutschland (Dortmund) especially developed the rail system in the 1930ies for nearly a wear-free negotiation of these radii. The flange of the outer wheel runs on top of the rail; the inner wheel is guided by a separate guide rail round the curve. As the outer wheel thus operates with a larger diameter wear is minimised.* *As today's large wagons cannot negotiate these curves they have become quite seldom.*

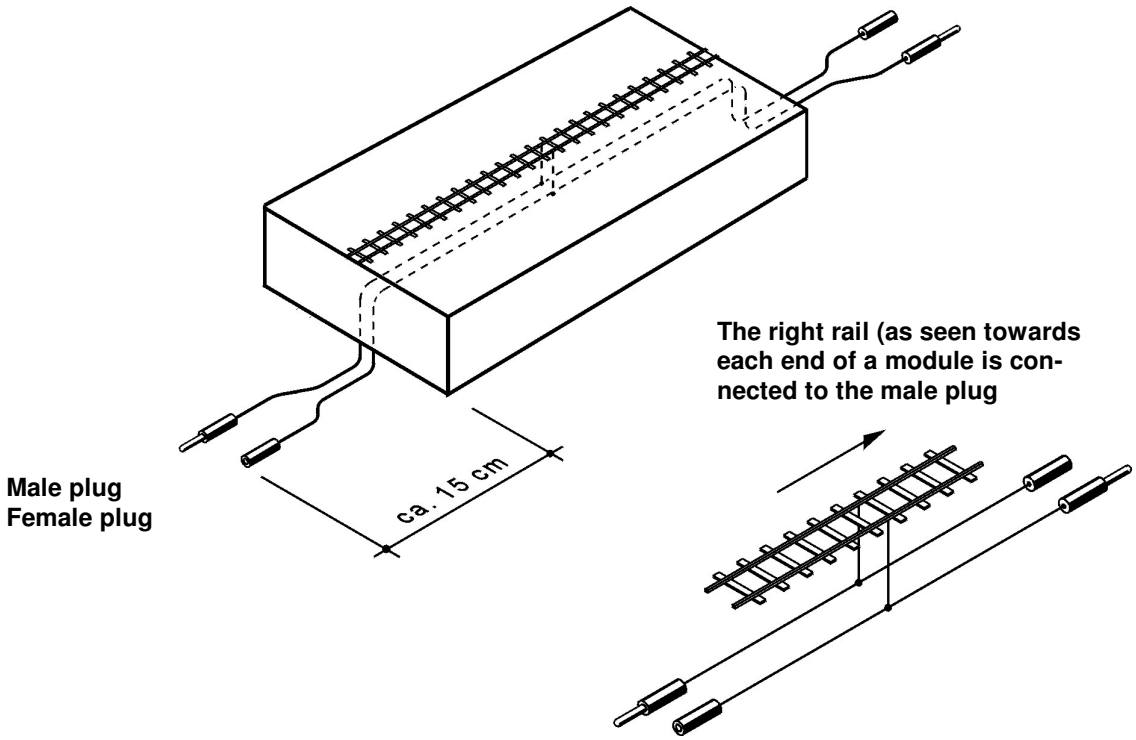
	Commitment:	Fig:	Explanation:
4.4	S-curves		*Between two curves in opposite direction there should always be a straight piece of rail to avoid any problems with the buffers. Thus also between modules with curves in opposite direction there should always become a straight module integrated in between.*
4.5	Curve super elevations should be avoided to not prevent the free arrangement of modules		*Curve super elevations are only permitted in modules that will always be erected as a group. On the other hand one has to be aware that this hampers the planning of thearrangement in a given space.*
4.6	Rectangular arrangement of track at the end of the modules	**4.5**	*It is very important that the tracks end rectangular directly at the module's end.* *Small imperfections of the track arrangement can be overcome by the adjustment of the bolts in the larger holes (3.5). Tracks will be ballasted right through to the end of each module. This ensures a harmonic picture and easy erection.* *Rails have to be secured specifically at the module's ends; preferably the rails are soldered to the heads of brass screws that are screwed from the top directly in line with the rails into the end profile.* *(Glueing here is NOT sufficient!).*



4.5 Fixing of rails at the end of a module

5 Module-Elektrics

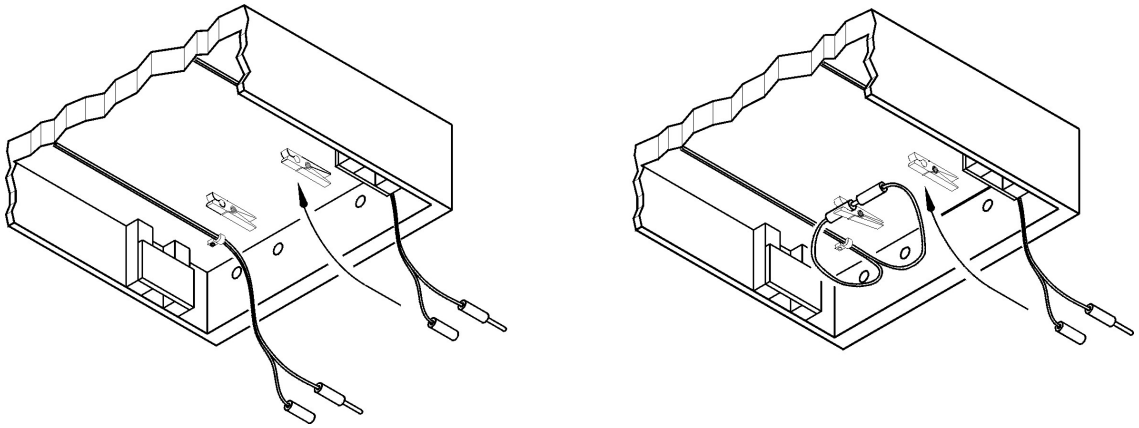
	Commitment:	Fig:	Explanation:
5.1	Two through-going cables for the power supply of the rails with – preferably – several connections to the rails in one module	**5.1**	*These cables are all needed for the safe power supply of the tracks and make rail connectors superfluous. These connectors are not being used in FREMO87 applications.*



5.1 Principal electrics of modules

5.2	In stations a booster connection has to be provided	*Each station is supplied by a DCC-booster to prevent shorts circuits from having a negative effect on the whole arrangement. Thus these can be restricted to be a local event. 4 mm plugs in the power supply of the station have to be provided therefore in a suitable place.*
5.3	The relation of the cables have to be made by the respective arrangement	*Each power supply cable should be arranged under its respective rail. This eases the understanding of a module and ensures a fast erection; it becomes especially important when the module owner is not present during the erection, as he may have to do something else.*

	Commitment:	Fig:	Explanation:
5.4	Cable-ends have to be provided with common 4 mm plugs (male and female) NO male plugs with a x-wise hole is to be used instead of a female plug!		*The connection with male and female plugs for the power distribution over modules are literally foolproof. Male plugs with an additional x-hole therefore are NOT allowed; moreover they may cause short circuits very easily. Plugs of the HIRSCHMANN Company have shown to be very reliable.*
5.5	Cables have to be 150 mm extending over each end of the module	**5.5**	*The additional cable lengths always allow for an electrical connection between modules. If higher end profiles were applied longer cable lengths would probably be required on each module end.*
5.6	The cable x-section should be at least 0,75 mm^2		*An ordinary twin-cable (applicable for 110/ 240 V) of loudspeaker-cable may be used. Highly flexible cables should be preferred.*
5.7	Clothes pegs have to be provided under the modules to allow for the tucking away of the cable ends during transport	**5.5**	*Wooden clothes pegs that have been hot-glued under the modules are a well proven method to get rid of free hanging cable ends during transport of modules. Male and female plugs from one end are plugged into each other and then inserted into the clothes pegs. These can also be used during operation to lift up free hanging cables under modules. To prevent e. g. catching in the cables when one has to duck-under to cross the module arrangement.*
5.8	Additional screw-in hooks (min. diameter 10 mm) should be foreseen under the modules for tucking away the LocoNet- and telephone-cables during operation		



5.5 Elektrics at the end of modules – fixing of cables for transport (normally only a twin cable would be needed)

	Commitment:	Fig:	Explanation:
5.8	Application of turnouts usable in DCC-applications with a polarity changed frog		*Turnouts have to be designed such that the switch tongues are not being supplied with power by the adjacent set rails – short circuits from the back of the wheel flange to the switch tongues thus cannot surely be prevented.* *Moreover the frog area has to be electrically isolated and it's polarity changed in parallel to the switching of the turnout by suitable means.*
5.9	For tracks that need to be isolated both rails would have to be isolated		*Basically gaps in the track are no longer required with the throughout introduction of DCC – apart from in the frog area of turnouts.*
5.10	Local operated switches		*Most stations that will be built in accordance to these standards will be provided with locally thrown turnouts. It has shown to be advantageous that turnouts can be operated from both sides of the modules to allow for an easier operation and arrangement of stations within a modular layout.*
5.11	Traffic control and switchboards		*We welcome the application of prototypical safety technology within the modules.*

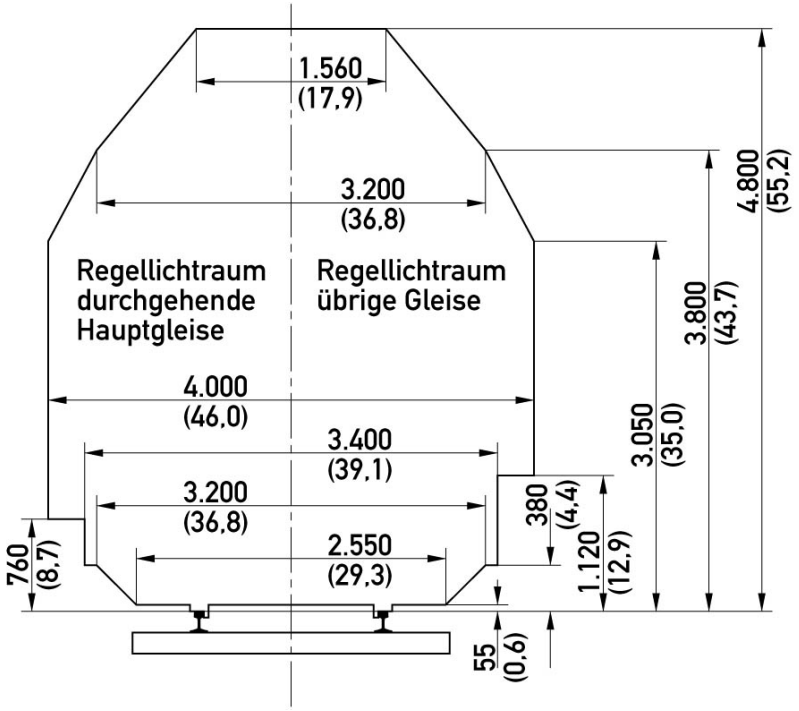
6 Elektrics – DCC and LocoNet

	Commitment:	Fig:	Explanation:
6.1	NO 110/ 230 V power cables should be integrated into modules		***Modules with integrated 110/ 230 V power supply cables will be excluded from any FREMO-meeting,*** ***The specifications for meeting participants (July 2006) apply.***
6.2	Only the DCC-digital system will be applied (as standardised by the NMRA); the bus-system for hand-held throttles and booster will be the LocoNet;		*LocoNet is a bus-system that was developed by Digitrax thus being not completely commercially independent.* *The application of the LocoNet is obligatory for Hand-sets and boosters. Rail voltage is 14 V to allow for reproducible speed adjustment of motive power; long addresses will apply and 128 steps for speed; This should be considered when providing DCC-components.*
6.3	For each operational section (i. e. a station, large industry etc) a DCC-booster has to be provided		*The booster should galvanic isolate rails and LocoNet. Lack of signal should be shown on the booster to prevent uncontrollable operation of motive power. A transformer should be provided for each booster that has to be in accordance to the respective standards and is NOT integrated into a module* *If only traction power equipped with coreless motors is applied 3 Amp transformers would suffice.*
6.4	Each operational unit should be fitted out with enough FRED-connections on BOTH sides as well as for the connections for the LocoNet below the module		***The Loconet has to be arranged in a throughgoing line; the operational unit should only be connected to it by a star point to enable easier fault finding in a layout.*** *The type of connections is described in detail in the module handbook.*
6.5	Je Betriebsstelle ist eine genügende Anzahl vorkonfektionierter Kabel für die LocoNet-Verkabelung vorzuhalten.		*All cables should be tested before their application for correct polarity (Tester circuits are being provided by some members of the FREMO and can be used at no charge at meetings.) All cables should be marked with their respective length and the owner's name.* *As these cables depend on the special situation of the respective station please refer to the module handbook for further recommendations.*

7 Motive Power and Wagons

7.1 General

	Commitment:	Fig:	Explanation:
7.1.1	Motive power and wagons should resemble prototypes which were in use in the above named periods 3b-4a		*Principally also wagons (and possibly also motive power) from other railroads and from other time periods may be used.*
7.1.2	Motive power and wagons have to be in optical and technical pristine condition		*When there is no operation schedule test runs may be carried out (after asking the module owners) with new or partially finished rolling stock or motive power.*
7.1.3	The prototypes profile should be maintained	**7.1**	*The prototypical profile should be maintained – this especially applies for the cylinders of steam locos that are generally arranged far to wide on the steam loco models following the NEM standards.* *The profile as shown below is applicable for standards gauge railways radii >250 m; for smaller radii the profile may be widened e. g. by 80 mm on the inside of the curve and 90 mm on the outside at a radius of 180 m.* *A test profile will be available during meetings as well as a loading profile.*



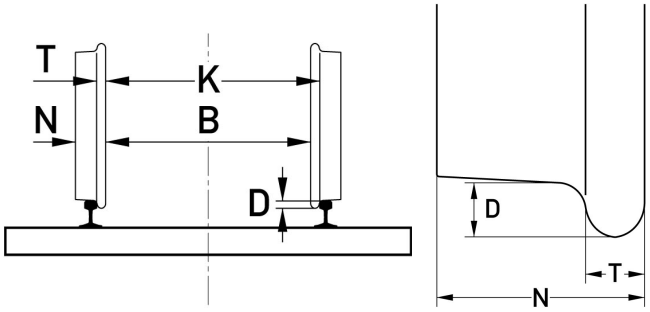
7.1 Standard profile for FREMO87

7.2 Chassis

	Commitment:	Fig:	Explanation:
7.2.1	Layout of gear boxes		*Even though some imperfections of not properly designed gears can be overcome with the application of DCC – the application of such wrong designed and possibly also noisy gears should definitely be avoided.* *The rule of thumb is that with a properly designed gear ratio the max. prototypical speed should not be exceeded by more than 20 % at 12 V DC.*
7.2.2	Three point suspension and springing of vehicles		*Not even with the prototype all rails are laid perfectly – module transitions, changes in temperature as well as flexible floors in sports halls quite often cause significant changes in vertical alignment with which the vehicles have to cope.* *For derailment-free operation of motive power as well as of cars at least a three-point suspension system should be applied on ALL vehicles – possibly combined with springing of axles. This especially applies for all long 2 wheel chassis and basically for all 3 wheeled chassis.* *Wagons with a short rigid wheel base may not cause problems – but their use may be restricted by their reliability to stay on the rails.* *Optimium traction and derailment-free operation of motive power can best be achieved with fully compensated chassis; this especially applies for multi-wheel steam locos.*

7.3 Wheel-Sets

	Commitment:	Fig:	Explanation:
7.3.1	Wheelset and wheel dimensions in accordance to the attached table		*Only wheel-sets may be applied that are in accordance to the dimensions as shown in the table below.* *It is obvious that the wheel-sets should be of the highest quality with very tight tolerances with regard to roundness and wobble.*



	Prototype EBO [mm]	1:87 [mm]	FREMO:87 (H0pur) [mm]	
Wheel standards				
K			15,92 – 16,00	Check gauge
B	1357 - 1363	15,59 – 15,67	15,55 (+0,05)	Back to back
B+ 2N	1617 - 1663	18,59 – 19,11	18,65 - 19,04	Front to front
N	130 - 150	1,49 - 1,72	1,55 - 1,72	Tire width
T	20 - 33	0,23 - 0,38	0,37 - 0,40	Flange width
D	25 - 38	0,29 - 0,44	0,32 - 0,35	Flange height
FR	12 – 15	0,14 –0,17	0,15	Radius tread/ flange
TC	1:20 / 1:10	3,2° / 6,4°	2,5°	Tread angle

7.3.1 Wheel dimensions FREMO87

7.3.2	Wheel set insulation respectively flanges to the insides of the wheels		*Insulated bushings on the axles should leave free a with between them of min 13.0 mm to allow for the transportation of the wagons also on narrow gauge bogies.* *Axle diameters should be between 1.6 - 2.0 mm.*
7.3.3	Solely application of wheel with profiles to both sides		*Also the backs of the wheels should have a profile to allow for a pleasant view also of the axle-work of vehicles.*

7.4 Weights

	Commitment:	Fig:	Explanation:
7.4.1	Min. weight of wagons		*To prevent derailments wagons should not be too light.*

The figures as in the following table have proven to be advantageous.:

4-axle wagons 80 g
2-axle wagons 60 g

Base weight	[g]	30
Extra-weight (for each mm of wagon length)	[g]	0,5
Min. length	[mm]	100
Max. length	[mm]	180
Correction factor for wagons that are shorter than the min. length		0,9
Correction factor for wagons that are longer than the max. length		1,2

Example:	Wagon of 140 mm length:	30 g + 140 x 0,5 g	= 100 g
	Wagon vnf80 mm length:	(30 g + 80 x 0,5 g) x 0,9	= 63 g
	Wagon of 200 mm length:	(30 g + 200 x 0,5 g) x 1,2	= 156 g

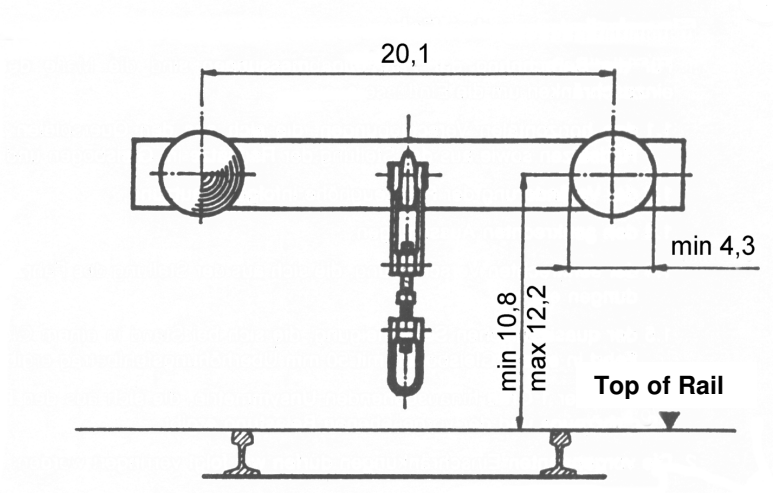
Recommendations in accordance to NMRA RP 20 (HP1 III/95, P. 24)

7.4.2	Centre of gravity		*Especially wagons that may also be transferred to the narrow gauge one should aspire a low centre of gravity to prevent the wagon from toppling over.*

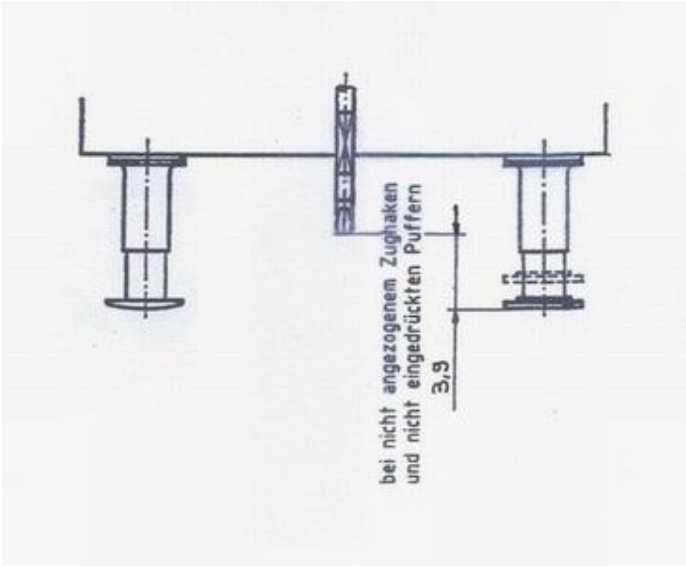
7.5 Couplings and Buffers

	Commitment:	Fig:	Explanation:
7.5.1	Reproduction of the hook and eye coupling, height over top of rail	**7.5.1**	*The standard hook-and-eye coupling as still is common on the Continent will be applied. The coupling should preferably be installed in the sprung version. Height over railhead in accordance to drawing 7.5.*
7.5.2	Spring buffers, height over top of rail	**7.5.1**	*Sprung buffers are a must – this especially applies for wagons to be transferred to the narrow gauge with their smaller radii. Height of buffers above railhead in accordance to drawing 7.5.*
7.5.3	Relative arrangement of buffers to the coupling and assembly	**7.5.2** **7.6**	*The single parts of the coupling have to be put together such that all parts are moving freely. The coupling chain has to easily follow gravity and adjust itself in a vertical line. For this it is obligatory to re-drill and ream all connecting holes. A minimum requirement is the free movement of the first two pieces of the coupling (as seen from the hook).*

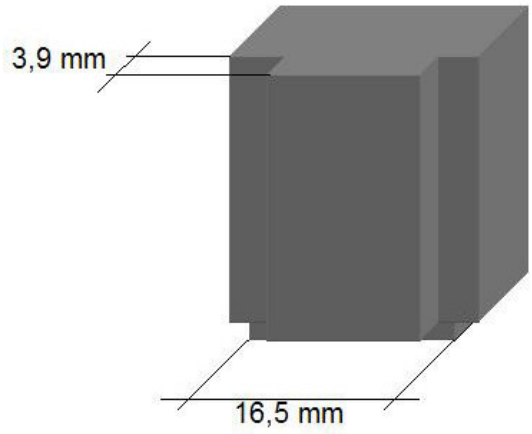
Commitment:	Fig:	Explanation:
		The hook has to be de-burred and any imperfections from the foundry-process have to be grinded away; the opening of the hook should be 0.6 mm. The eye should be treated such that the diameter that willfit into the hook doesn't exceed 0.4 mm. For adjustment of the front-of-hook – buffer distance a gauge is recommended as can be seen from fig. 7.6..



7.5.1 Buffers and coupling arrangement (measurements in mm)



7.5.2 Buffers and coupling arrangement (measurements in mm)



7.6 Gauge for arranging the front of hook relative to the buffers (measurements in mm)

7.6 Motive Power Electrics

	Commitment:	**Fig:**	**Explanation:**
7.61	Motive power has to be provided with a DCC decoder		*All motive power should be equipped with suitable DCC-decoders. As the technology in this field advances fairly fast experiences members of FREMO should be contacted before choosing for a specific decoder. People from the FREMO-DCC-group would be prepared to give any support needed here.* *Only decoders will be allowed that allow the adjustment of 128 speed steps and long addresses to be used. Moreover decoders should have a high-frequency and load-dependant control for use with the operation of core-less motors.* *Sound decoders may principally be used but their application should always be checked before with the respective DCC-responsible FREMO member.*
7.6.2	Power pick-up		*Power pick-ups on motive power should be easily accessible for cleaning as experience has shown that especially in the big arrangements common to FREMO dirt gets easier picked-up and collected there than while operating a home layout.*

	Commitment:	Fig:	Explanation:
7.6.3	Frames should be potential-free		*Buffers and/ or couplings may establish an electrical connection between 2 vehicles. In case only wheels would be insulated on one side – this especially applies to all full-metal locos like e. g. from WEINERT or etched cars – a short circuit may occur via coupling/ buffers if the non-insulated wheels are standing on opposite rails. If the vehicle doesn't allow for a both-sided insulation of the wheels buffers and couplings have to be installed electrically insulated from the chassis.*

8 Operation

	Commitment:	Explanation:
8.1	Drawing of module	*For planning of meetings each module should be precisely drawn. The process today becomes much easier when an Autocad-drawing is used (including name of module and of module owner).*
8.2	Station data sheet of an operation unit	*To enable the demand of freights from other operation units/ stations each of these units should be provided with a data-sheet that provides background-information on the unit as well as gives hints for possible freights.*
8.3	One Telephone for each operation unit	*Each operation unit/ station should be provided with an analogue telephone.* *The FREMO87-group have their own analogue telephone system for managing and connecting to analogue telephones.*
8.4	Fast-Clock-System	*A separate fast-clock system is also provided within the FREMO87-group*
8.5	Cleaning of rails has to be carried out by the module owners	***Due to the increased amount of details that will be installed also next to the rails cleaning of rails should only be carried out by module owners resp. with his expressive consent!***
8.6	Operation with wagon cards as common within FREMO	*For this point please refer to the well known and widespread used rules that include e. g. wagon cards for each freight wagon as well as freight bills for the stations etc.* *Cards also have to be provided for the motive power.*
8.7	Rail locks	*Rail locks have to be checked and observed - like any other signals.* *When driving over a rail lock the loco driver will have to pay a fine on 5.0 € and the train operator a fine of 2.5 €. The money goes to FREMO e.V. for supporting new recruits.*
8.8	Start of operation	*Basically before start of operation an introduction to the whole layout will be carried out.*

9 Exclusion Criteria

	Commitment:	**Explanation:**
9.1	Modules and/ or vehicles that hamper or obstruct the smooth operation by not being in accordance with the valid FREMO87 standards should be excluded from meetings until the faults/ shortfalls have been overcome	*Smooth and satisfying operation for all participants can only be ensured by the application of reliable modules, tracks and rolling stock. A prerequisite is that **all** used parts fit and work together.* *The standards as in front of you (that by the way was developed practically and is not solely based on theory) acts as a base for that. The whole modular layout philosophy is based on the close cooperation of all participants. Cooperation is the crucial point for a successful module operation.* *The growing size of modular layout meetings and the ever increasing distances to get to the meetings as well as the improving quality with regard to landscaping and technology require an ever growing effort – cost and time-wise - from the model railroader. This leads to the conclusion that limits have to be set and criteria have to be defined under which modules and rolling stock probably will have to be excluded from arrangements.* *It would be detrimental (and also not very companionable) if the smooth operation of a whole layout and thus the fun in operating it would be sincerely disturbed by the integration of modules that are not in accordance to standards (e.g. with regard to profile, turnout angle, curve radii, faulty electrics etc.) thus hampering the operation. The same applies for rolling stock and motive power that doesn't operate highly reliable thus also causing permanent derailments and probably also damages to module installations.* *Only the strict application of the standards ensures the aspired smooth operation. Who thinks that he can do without these guidelines and doesn't stick to them should therefore not be too disappointed if his module(s) of rolling stock/ motive power has to be excluded resp. taken of the arrangement.* *There will be no specifically assigned authority for that no censoring and no devaluation due to specific quality or styles. Exclusion will only apply if a permanent malfunction is being found that can not easily be rectified.*

10 Recommendations

The following recommendations are no specific standards as modules may be operated without them and as other solutions may be possible; nonetheless these topics were found to be important in practice for improving the operation on a modular layout. It is therefore sincerely recommended to follow these recommendations.

	Recommended:	**Explanation:**
10.1	Sub-structure of tracks I	*In the past we made quite often the mistake to apply cork as a sub-roadbed for the tracks between the module ends on which the rails are being fixed. The cork shrinks over time thus creating "ski-jump" situations that will hamper the smooth operation. This can be avoided if the sub-roadbed is lead directly to the module end.*
10.2	Sub-structure of tracks II	*Moreover the application of cork is definitely NOT recommended here.* *Today the gearboxes have become so silent that an additional sound insulation on the modules is no longer required. It will be better to install the tracks directly on the plywood or on separate plywood sub-structures that maintain their size and volume. This is especially advantageous with switches that can be build separately and later become integrated into the module.*
10.3	Landscaping should preferably end at the end of an open track module	*There should be only the ditches next to the tracks leading from one module to the adjacent one. There should be only small plants and bushes being used near the module ends. Roads, streets, rivers and other elements of the landscape should not be used to cross module ends but be lead out to the front of rear end of a module.* *Several modules that have to be grouped together due to their specific landscaping may hamper the planning of an arrangement significantly probably even prevent the sensible use of the available space and moreover are not conforming to the idea of the free exchangeability of modules.* *The H0pur-standard requires SILFLOR-material to be used at the module ends. It has to be noted that other material may also lead to good results.*

	Recommended:	Explanation:
10.4	Operational units/ stations should be generously designed	*Operational units/ stations – if not modelled following a prototype anyway – should be designed generously to support the idea of prototypical operation and switching within these areas.*
10.5	Operational unis/ stations should be of such a design that they can also be used in other time periods as the above named preferred one	*This enables the possibility – if enough periods type rolling stock is supplied by members – that also operation may be carried out following other periods than the generally preferred one.*
10.6	"Kinght"-rule	*Operational units/ stations are generally a lot more interesting to build than open track modules; to prevent that a meeting solely consists of station after station directly following each other each owner of station should aspire to provide twice the length of open track compared to the station length.*
10.7	Motive power should be equipped with fly-wheels and coreless motors	*The application of core-less motors (e.g. FAULHABER, ESCAP, MAXON o. e.) together with a correspondingly sized flywheel is sincerely recommended. These motors – naturally in combination with a respective gearing - generally allow for very good speed control especially while switching. The generous flywheel further smoothes the operation and helps to overcome small electrical contact problems.* *Decoders should be of the high-frequency type that are especially available to be used in conjunction with these motors.*