DESIGN REPORT
Group V8G

Designed by:

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Under the guidance of:

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Contents

Name of the Machine

Railway Cart

Purpose of the Machine

Railway carts are used for the transportation of cargo. This cart is attached to the front of the train, between the winch and the rest of the wagons. We expect all the wagons to move with the velocity at which they are being pulled, but it may not always be the case. (Example- during travel along an inclined plane the wagons move with a velocity greater than the pulling velocity) Therefore, to regulate the velocity of the wagons, the railway cart in question is used.

Design Objective

To design a safe railway cart that regulates the velocity of the 26 wagons attached to it. It should be done in such a manner that the train can be stopped within 1m @ 2 minutes.

Broad Design Specifications

- Has 26 wagons of 100 tonnes each attached to it
- Velocity of cart- 0.125m/s
- Stopping distance- 1m
- Wheels and axle- According to Indian railway standards

Calculation of Design Load

1. Braking load

The stopping distance, s= 1m and
the velocity of the cart, v= 0.125m/s
Total mass, m= 26*100*1000kg
therefore, acceleration, a= v^2/2s= 0.00781m/s^2 and
The breaking load, F= ma= 20300N

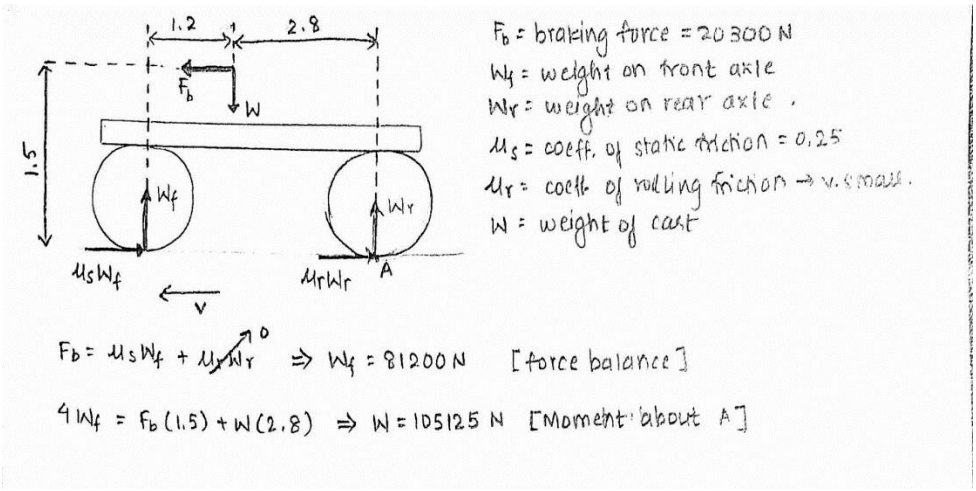
2. Weight of Cart

- Without dead weight

braking force= frictional force
where the coefficient of friction, mu= 0.25
20300= mu*(weight of the cart)
therefore, the weight of the cart, *W= 81200N*

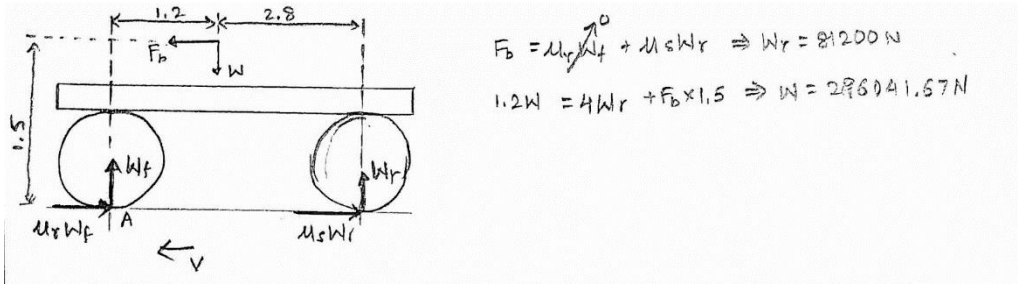
- With dead weight

Considering a mass distribution of 7:3 and brake on the front axle and a distance of 4m between the axles of the wheels



Centre of gravity lies at 1.2m from the front axle where coefficient of static friction on the front

wheel, mu(s)= 0.25
balancing forces (weight on front axle, W(f)=81200N) and moment about the centre of gravity, we get weight of the cart, *W= 105125N*



(Considering 7:3 mass distribution and brake on the rear axle, the weight of the cart comes out to be *296041.67N.* The case where the mass of the cart is less; is chosen.*)*

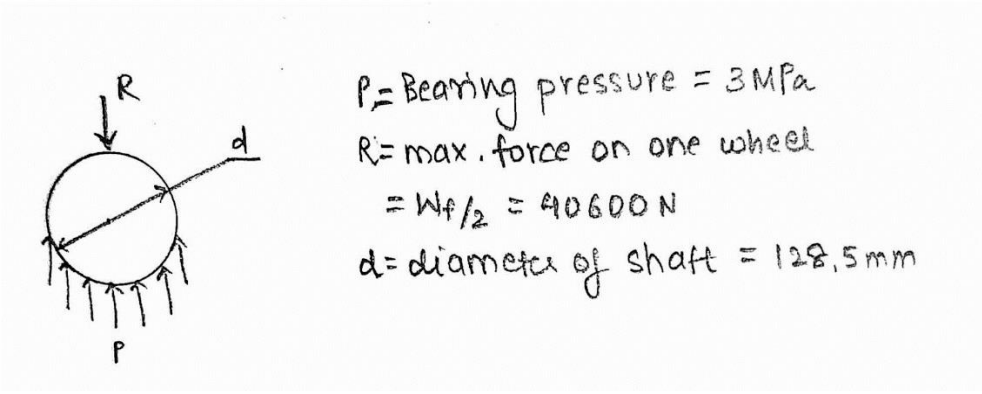
The final weight of the cart is W= 105125N

Design on Machine Elements

No. of wheels

material of wheels- cast steel (E= 215GPa, v= 0.265)
material of track- rolled steel (E= 186GPa, v= 0.287)
radius of wheel, r(w)= 0.5m
Syc= 250MPa, fos= 2, P= Syc/fos= 125MPa
Maximum axle load =20.32 tonne
Maximum bearing load by wheel,
F= Maximum axle load/2= 10.16 tonne
Number of wheels= total load/F = 4

Bush bearing



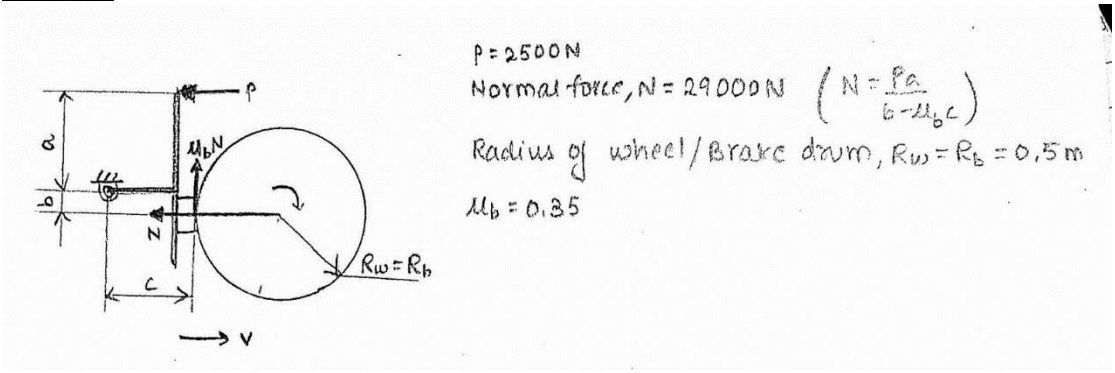
Diameter of shaft where bush is to be placed, d= 128.5mm (Indian Railway Standards)
Bearing pressure, p= 3MPa
Maximum force on one wheel, R= W(f)/2= 40600N
using, p=R/(l*d) we get,
length of the bush, l= 105.32mm
radius of shaft, r= d/2= 64.25mm and c/r= 0.001,
therefore c=0.06425mm
inner diameter of bush, d(i)= d+2c= 128.6285mm

thickness of bush, t= 2.54mm

outer diameter of bush,

d(o)= d(i)+2t=133.7085mm~134mm

Brake



Placing the drum brake on the front axle

The brake is self-energizing in nature

weight on each front wheel, R= 81600/2= 40600N

coefficient of friction between wheel and track, mu= 0.26

radius of wheel, r(w)= 0.5m

Braking torque, T= mu*R*r(w)= 0.25*40600*0.5= 5075N

T= (a*mu(b)*P*R(b))/(b- mu(b)*c)

where **R(b) i.e radius of brake drum = r(w) = 0.5m**,

b =125mm,

mu(b) i.e friction coefficient between wheel and brake shoe= 0.35,

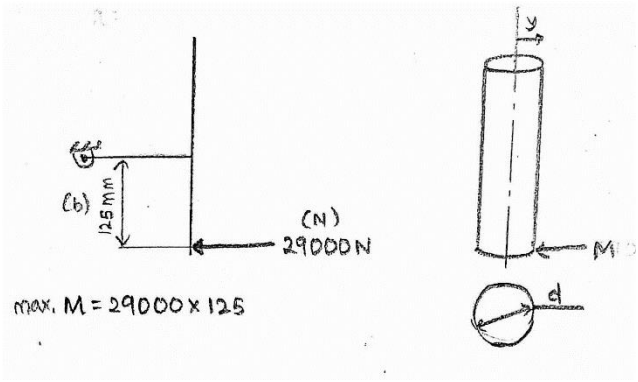
P= 2500N

For self-energizing, b < mu(b)*c i.e c > 125/0.35= 375mm

hence, taking **c= 500mm,**

we get **a= 580mm**

Brake Lever Dimensions



Material- mild steel
Maximum bending moment on the lever, M= N*b
M=29000*125= 3625000Nmm
sigma(permissible)= 400/fos= 400/2= 200MPa
sigma= M*y/I
for a circular cross section, I/y= pi*D^3/64
200= 3625000*64/ pi*D^3
the diameter of the brake lever, **D= 71.75mm ~ 72mm**

Bolts on axle housing

material- mild steel
(Shear Stress, Tao(s)= Syt/2= 400/2= 200MPa)
Permissible Shear stress,
Tao= Tao(s)/fos= 200/2= 100MPa
force on each bolt, f= 20300/2= 10150N
using Tao= f/area of bolt, we get
diameter of bolt, d(c)= 11.37mm ~12mm
taking thickness of housing= 3*d= 36mm

Bolts on axle cap

Material- mild steel (Syt= 400MPa)

Permissible tensile stress,

sigma= Syt/fos= 400/2= 200MPa

Axial load= 0.2*F= 4060N

Axial load on each bolt, p'= 4060/4= 1015N

using sigma= p'/area of bolt, we get

diameter of bolt, d'= 2.54mm ~5mm

length of bolt, l'= 1.5d'= 7.5mm

Cross Section of chassis (Longitudinal beam)

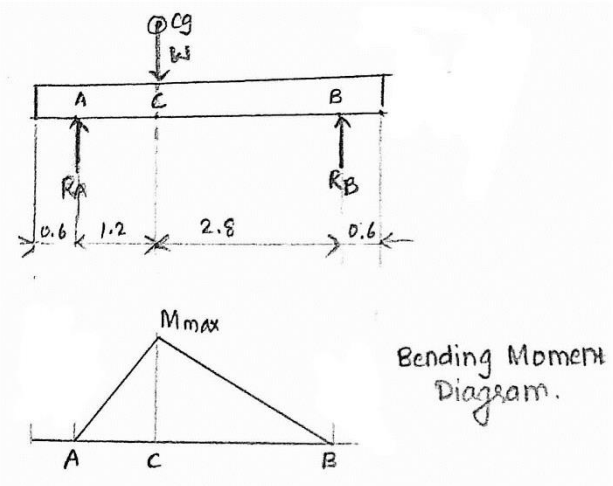
material- mild steel (Syt= 400MPa)

Permissible tensile stress,

sigma= Syt/fos= 400/2= 200MPa

Considering the entire weight of the vehicle(W=105125N) at the centre of gravity (1.2m from the front axle), and reaction forces Ra, Rb at the front and rear wheel respectively.

Weight on one longitudinal bar= W/2= 52562.5N (in the line of Cg)



Balancing forces and moment about the centre of gravity, we get

Ra= 36793.75N and Rb= 15768.75N

Calculating the maximum bending moment based on the values above,

M(max)= 44152.5Nm

sigma(b)= M/z= 44152500/z

We know that pulling force, F(p)= 20300N

sigma(p)= F(p)/Area= 20300/A

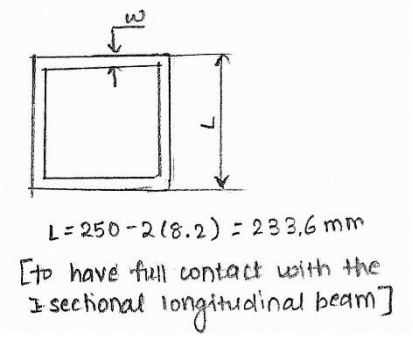
sigme(b)+ sigma(p)= sigma

i.e.44152500/z+ 20300/A= 200 (where z and A are in mm)

The I-section beam suitable for the above condition is

ISLB 250(h=250mm, b=125mm, tf= 8.2mm, tw= 6.1mm)

Cross section of chassis (Lateral beam)



width of the section, w= 8.2mm

Compression Spring

material- En 10277 (spring steel)

ultimate tensile strength, S(ut)= 1200MPa

tao= S(ut)/2= 600MPa

E= 212 GPa, v= 0.29 at 20 deg celsius

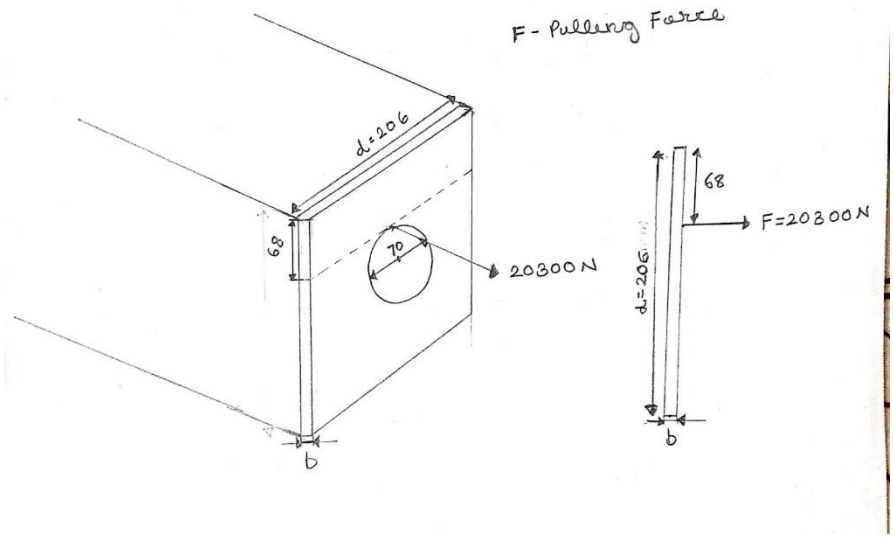
G= E/(2(1+v))= 82.17 GPa

c= D/d= 6;

where D is the mean diameter of the coil and d is the diameter of the spring

k= (4c-1/4c-4)+ 0.615/c= 1.2525
tao= k*(8*P*c/pi*d^2)
solving for d, we get **d= 25.45mm~ 26mm**
since D/d= 6, **D= 156mm**
deflection = (8*P*(D^3)*N)/(G*d^4)= 15mm
solving for number of active coils,N, we get **N=0.91~ 1**
Using square and grounded ends;
so the **total number of coils, N(t)= N+2= 3**
Solid length of the spring= N(t)*D= 78mm
free length of the spring= 94.5mm

Width of box



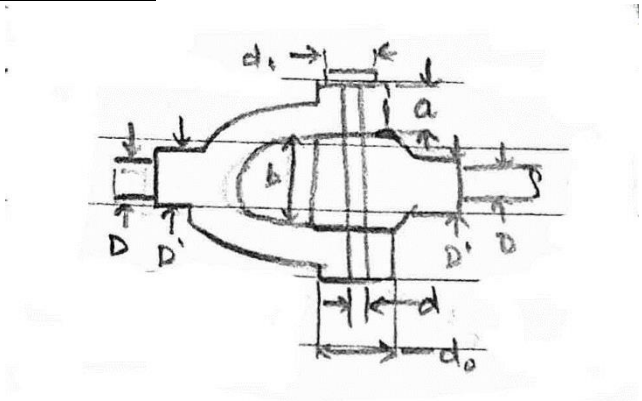
Material used- mild steel
Ultimate Yield Stress = 400MPa
Tensile strength(σ) = 400/FOS = 400/2 =200MPa
Pulling force(F)=20300N
Max bending moment(M)=F*68=20300*68
d=206mm

Bending Stress(sigma) = M*y/I
200=(20300*68*b/2)/(db^3/12)
width of box(b)=(20300*68*6/206*200)^½
b=14.17mm~15mm

Bolts for attaching box with chassis

material- mild steel (Syt= 400MPa)
Permissible tensile stress,
sigma= Syt/fos= 400/2= 200MPa
F= 20300N
Axial load on each bolt, p'= 20300/2= 10150N
using sigma= p'/area of bolt, we get
diameter of bolt, d= 8.04mm ~ 9mm
length of bolt, l = 35mm

Pin joint(Knuckle)



Material used - steel
Ultimate Yield Strength = 400 MPa
Tensile strength = 400/F.O.S = 400/2 = 200 MPa
Shear Strength = σ/2 =100 MPa
D=root(4p/π *σ(t)) =11.37 ~ 12mm

D’=1.1D=13.2mm

a=0.75D=9mm

b=1.25D=15mm

Diameter of pin,

d= max(√(2p/**π*****τ**),$\sqrt[3]{}$((32/p**π******σ*****(b))*(p/2)((b/4)+(a/3)))

= max(11.37,15.17)

d= 15.17 ~ 16mm

d_o=2d= 32mm,

d_1= 1.5d =24 mm

sigma’$_t$= P/b(d_o-d) =84.58 < sigma(t),

sigma’$_c$=84.58=tao ’1 <sigma$_c$, sigma

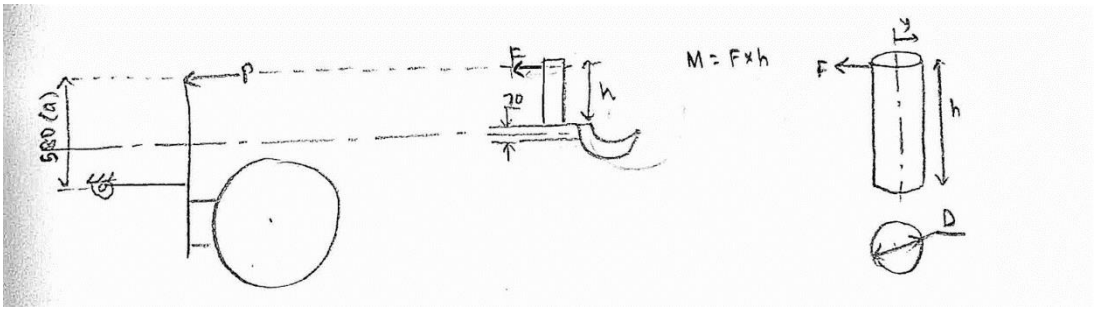
It is a safe design for eye

sigma”$_t$= P/2a(do-d) =70.48=sigma’’$_c$

=tao $_1$”< sigma$_t$, sigma$_c$,

It is a safe design for fork

Vertical rod



The height of the point of force on the rod from the hook(h) must coincide with the height ‘a’ of the brake lever, h= 441.1 mm

Maximum bending moment on the lever, M= F*h

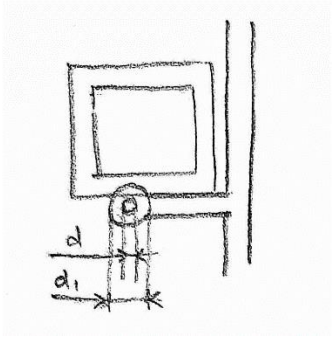
M=20300*441.1= 8954330Nmm

sigma(permissible)= 400/fos= 400/2= 200MPa
sigma= M*y/I
for a circular cross section, I/y= pi*D^3/64
200= 8954330*64/ pi*D^3
the diameter of rod, **D= 96.99mm ~ 97mm**

Horizontal rod

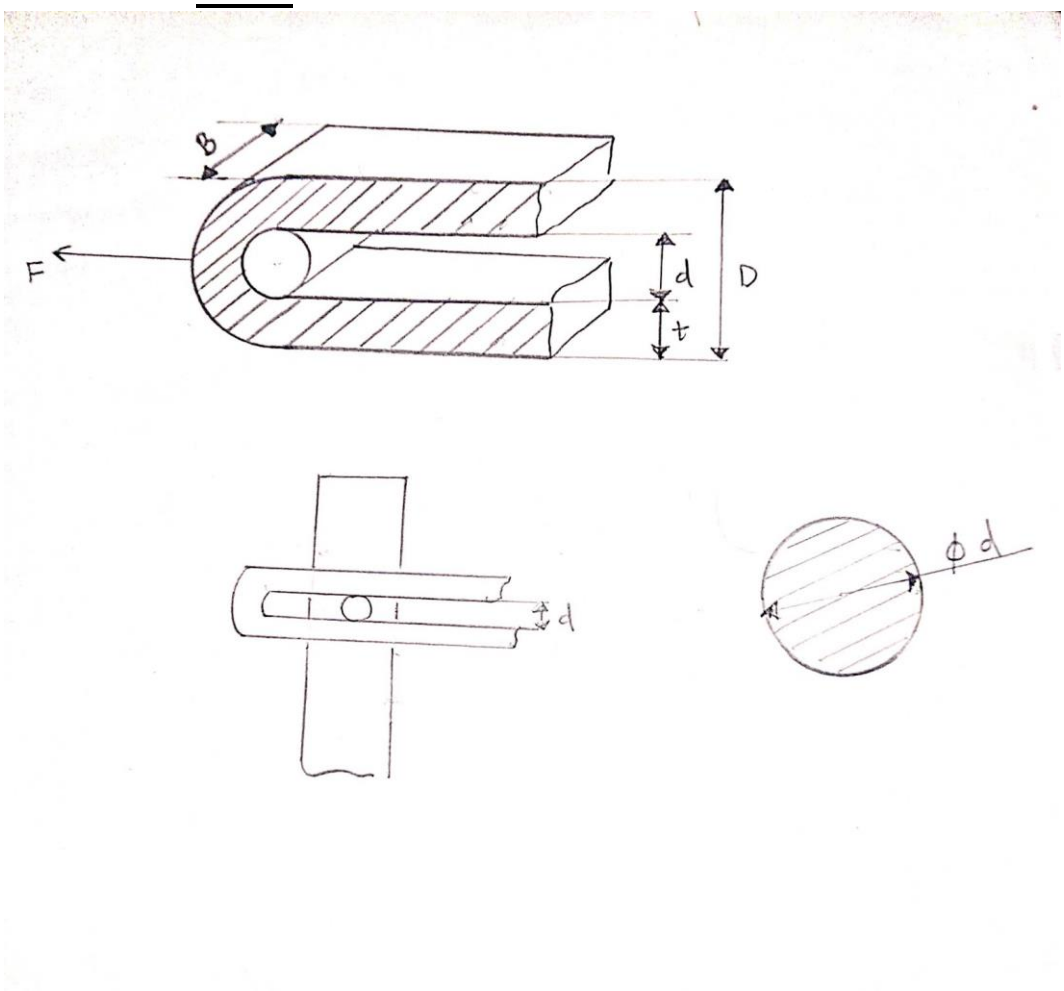
Tensile strength= 400/F.O.S = 400/2 = 200 MPa
Tensile strength= F/A
F= 20300N, and A= (pi*d^2)/4
Solving for diameter of rod, d;
we get, **d= 11.37mm~ 12mm**

Pin joint for brake lever



Material -Annealed steel (Syt=520Mpa)
Shear strength= 260 MPa
Tao(permissible)=260/2=130Mpa
Moment, T= N*b= 29000*125
tao= (pi*(d^3)*T)/16
solving for diameter, d; we get
pin diameter, d=52mm
boss diameter,
d(1)=1.6*d=81mm

Brake Handle



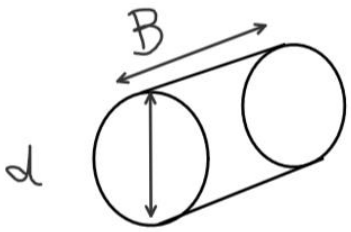
Stresses on pin of handle

Area= π d^2 FOS=2

τ(shear)= F/A

200/FOS= 20300/(π d^2/4)

d= 16.07 ~ 17mm



Stresses on slider

Area= B x t

σ(compressive)/FOS= F/A

400/2= 20300/B x t

t= 16.9 ~ 18 mm

τ= F(compressive on collar)/Area

400/2= 20300/18 x B

B =5.6~ 6 mm

Hook

Working Load- 30 tonnes

Weight Each- 46.7 kg

Specifications of the Machine

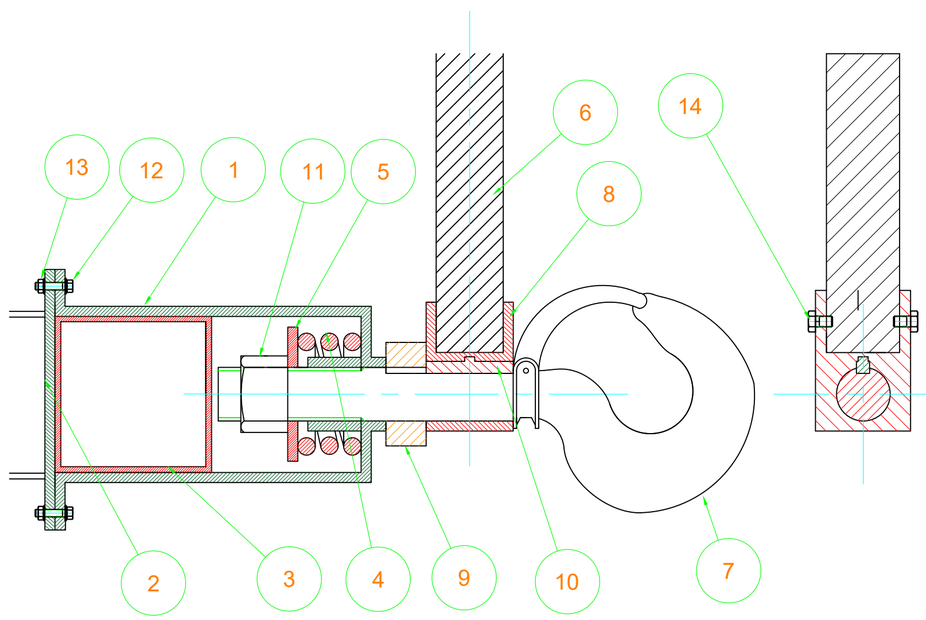
1. **Overall Dimensions:** (6.45*2.13*1.22) m^3

2. **Power Requirement:** 2537.5 W

3. **Operational Specifications:**
    - The cart maintains a velocity of 0.125 m/s
    - The stopping distance is 1 m
    - The cart is subjected to only linear motion

SUBASSEMBLY DRAWINGS

1.Spring Hook Assembly



Part List

ITEM	QTY	Part Designation	Part Name	MATERIAL
14	2	SHA014	Bolt	EN S275
13	2	SHA013	Flanged Nut	EN S275
12	2	SHA012	Screw	EN S275
11	1	SHA011	Nut	EN S275
10	1	SHA010	Single Headed Feather Key	EN S275
9	1	SHA009	Hook Collar	EN S275
8	1	SHA008	Bar Pocket	EN S275
7	1	SHA007	Hook	-
6	1	SHA006	Vertical Bar	EN S275
5	1	SHA005	Spring Collar	EN S275
4	1	SHA004	Spring	EN 10277
3	1	SHA003	Horizontal Chasis beam	EN S275
2	1	SHA002	Back plate	EN S275
1	1	SHA001	Spring Box	EN S275

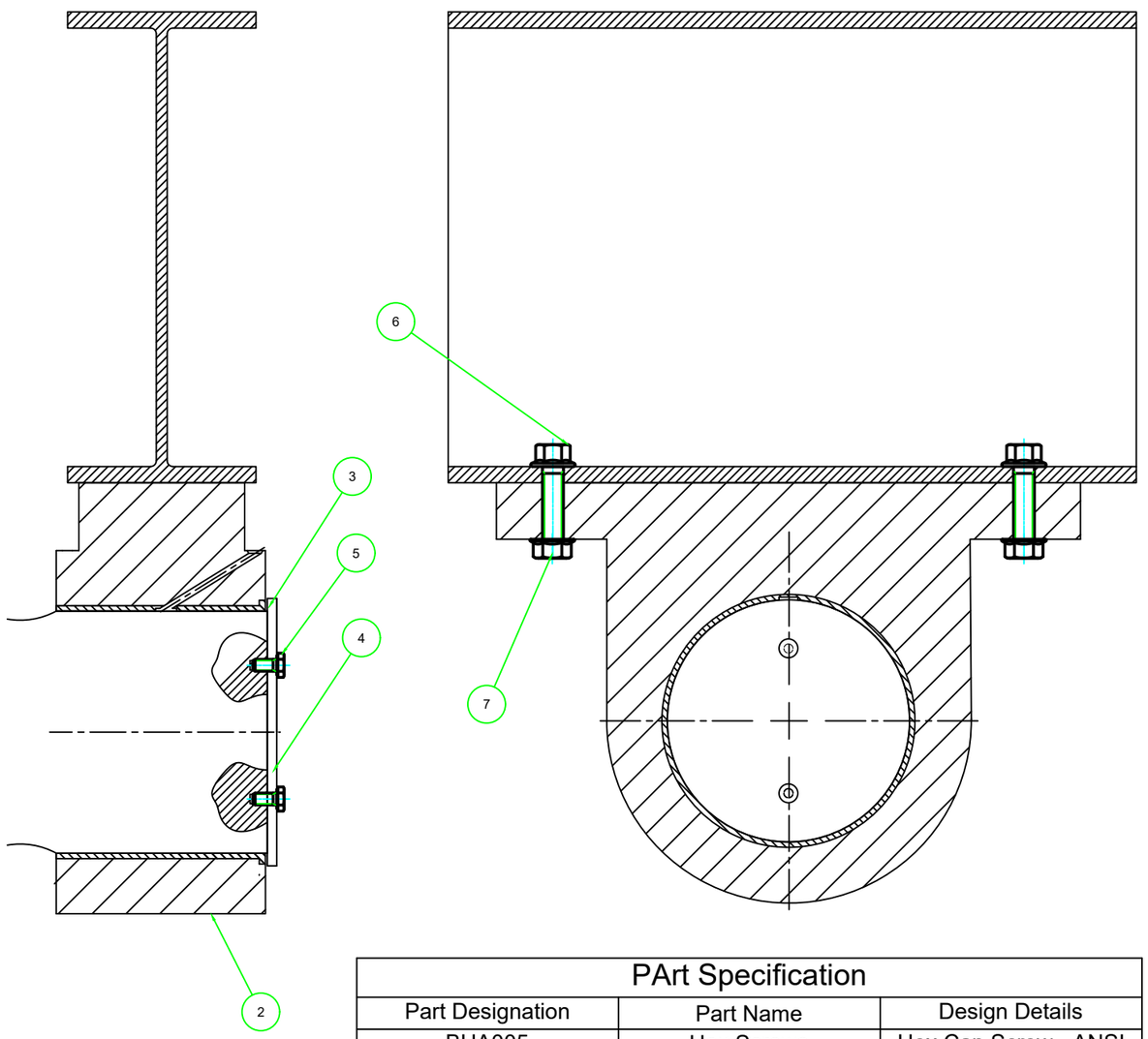
Parts List

Part Specification

Part Designation	Part Name	Part Details
SHA007	Hook	Hook size 16;Crosby BL-K and BL-I / LLSH-2407
SHA0011	Nut	M114.11 X 70
SHA012	Screw	7/16 x14 x1 3/4
SHA013	Flanged Nut	7/16 " 14 UNC
SHA014	Heavy Hex bolt	ANSI B18.2.1 - 1/2 - 13 - 6

Owner	MSD Group V8G		
Title of Sheet	Spring Hook Assembly		
	material	Quantity	Scale
			1:4
All Dimensions are in mm		Sheet no. - 1	

2. Bush Housing Assembly

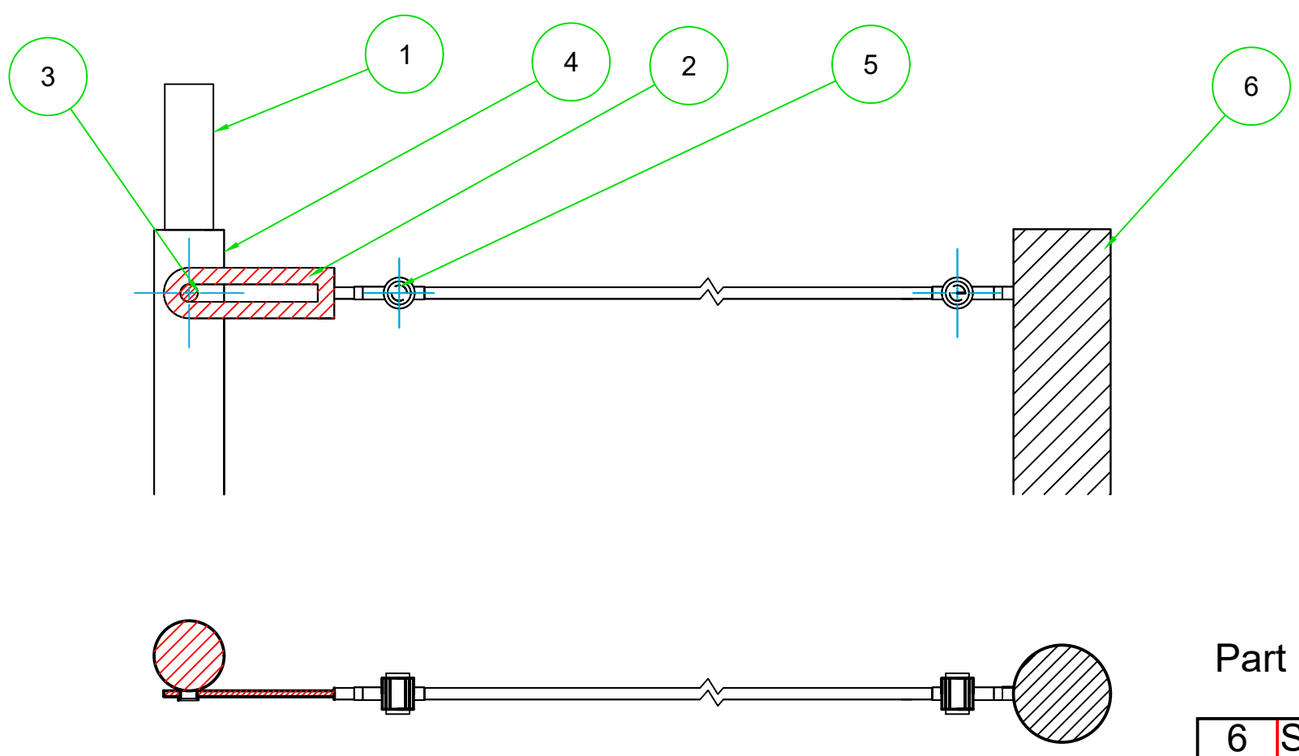


PArt Specification		
Part Designation	Part Name	Design Details
BHA005	Hex Screws	Hex Cap Screw - ANSI B18.2.1 - 1/4 - 20 - $\frac{1}{2}$
BHA006	Housing Screws	Hex Flange Screw - Regular Thread - Inch - IFI 111 - 1/2 x 13 x 1 $\frac{3}{4}$
BHA007	Housing Flange Nut	Hex Flange Nut - UNC - IFI - 1/2 - 13

Item	Qty	Part Designation	Part Name	Material
7	2	BHA007	Housing Flange Nut	EN S275
6	2	BHA006	Housing Screw	EN S275
5	2	BHA005	Hex Screws	EN S275
4	1	BHA004	Axle cap	EN S275
3	1	BHA003	Bush	SAE 841
2	1	BHA002	Bush Housing	EN S275

Owner	MSD Group V6A		
Title of Sheet	Bush Housing Assembly		
	material	Quantity	Scale
			1:1
All Dimensions are in mm		Sheet no. - 2	

3.Slider Knuckle Rod Assembly

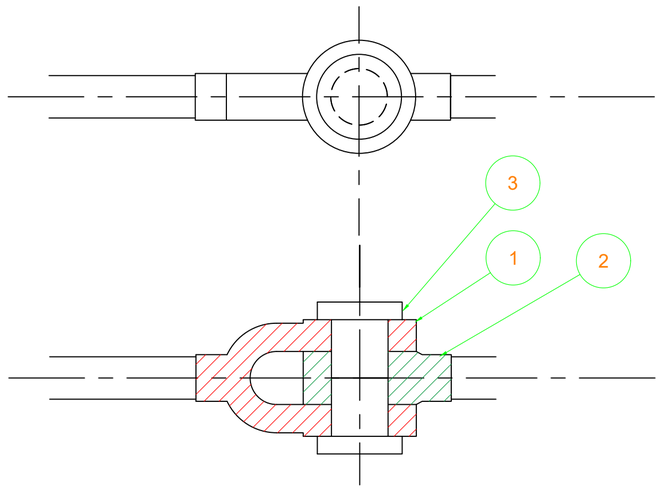


Part List

Item	Part Designation	Part Name	Qty	Material
6	SKR006	Vertical Rod	1	EN S275
5	KPA	Knuckle Pin Subassembly	2	ASTM A27 GRADE 60-30
4	SKR004	Main Brake Lever	1	EN S275
3	SKR003	Slider Pin	1	EN S275
2	SKR002	Slider	1	EN S275
1	SKR001	Brake handle	1	EN S275

Owner	MSD Group V8G		
Title of Sheet	Slider Knuckle Rod		
	material	Quantity	Scale
			1:4
All Dimensions are in mm		Sheet no. - 3	

4.Knuckle Pin Assembly

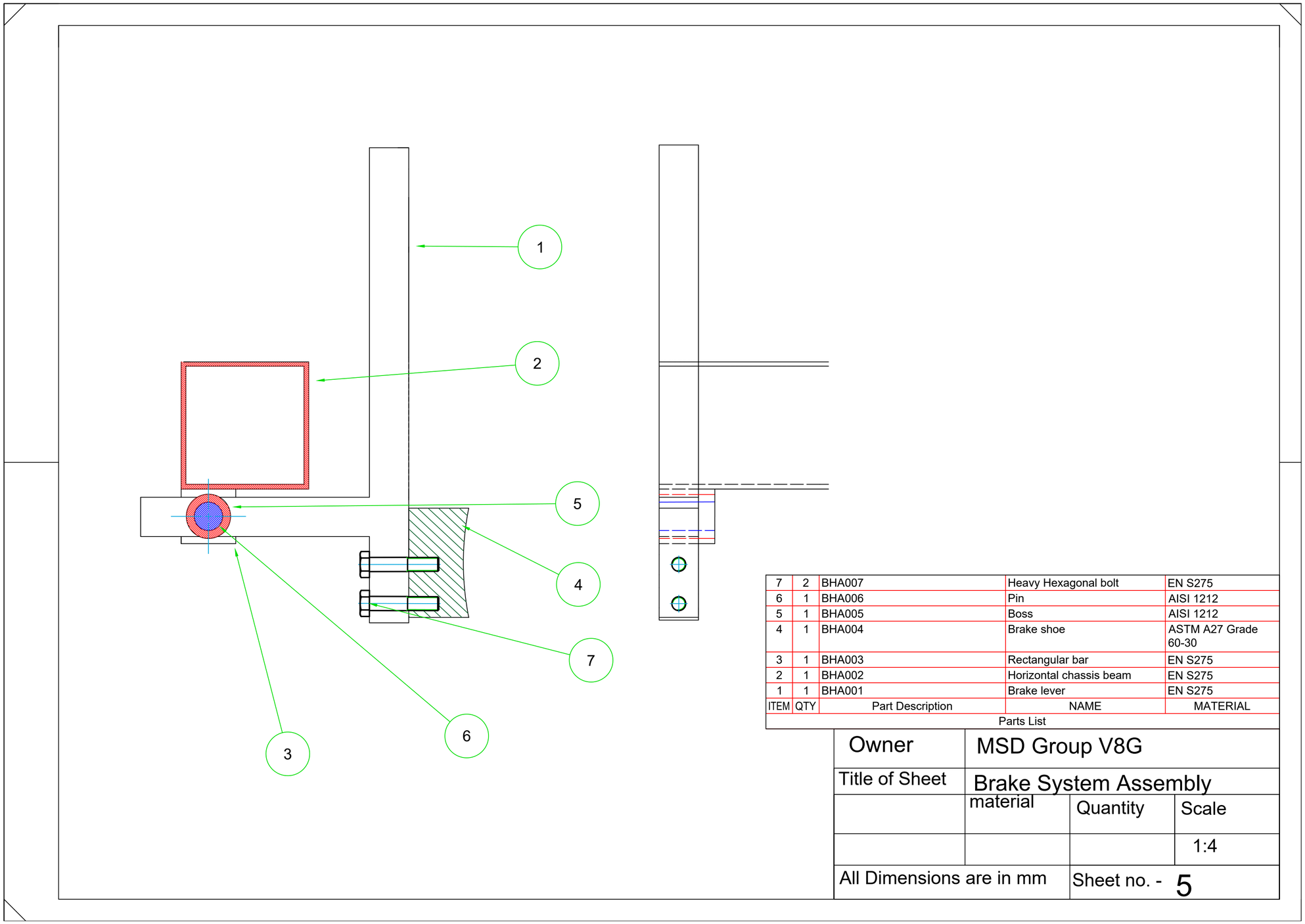


ITEM	Part Designation	Part Name	MATERIAL	QTY
3	KPA003	Pin	EN S275	2
2	KPA002	Eye	EN S275	2
1	KPA001	Fork	EN S275	2

Parts List

Owner	MSD Group V8G		
Title of Sheet	Knuckle Pin Assembly		
		Quantity	Scale
			1:1
All Dimensions are in mm	Sheet no. - 4		

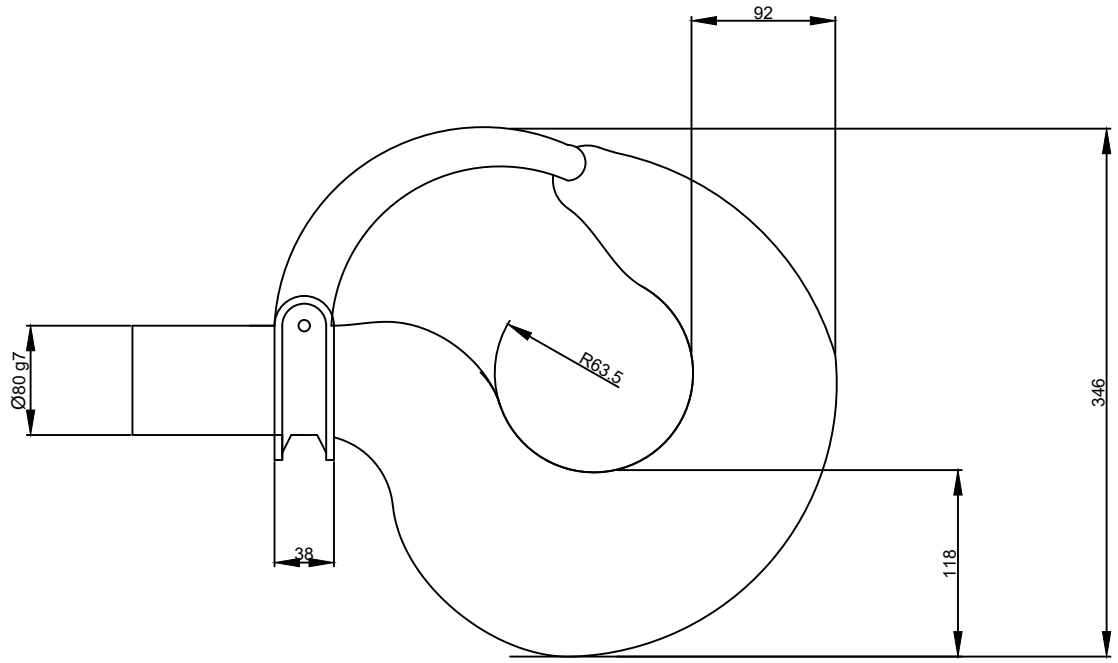
5. Brake Assembly



ITEM	QTY	Part Description	NAME	MATERIAL
7	2	BHA007	Heavy Hexagonal bolt	EN S275
6	1	BHA006	Pin	AISI 1212
5	1	BHA005	Boss	AISI 1212
4	1	BHA004	Brake shoe	ASTM A27 Grade 60-30
3	1	BHA003	Rectangular bar	EN S275
2	1	BHA002	Horizontal chassis beam	EN S275
1	1	BHA001	Brake lever	EN S275

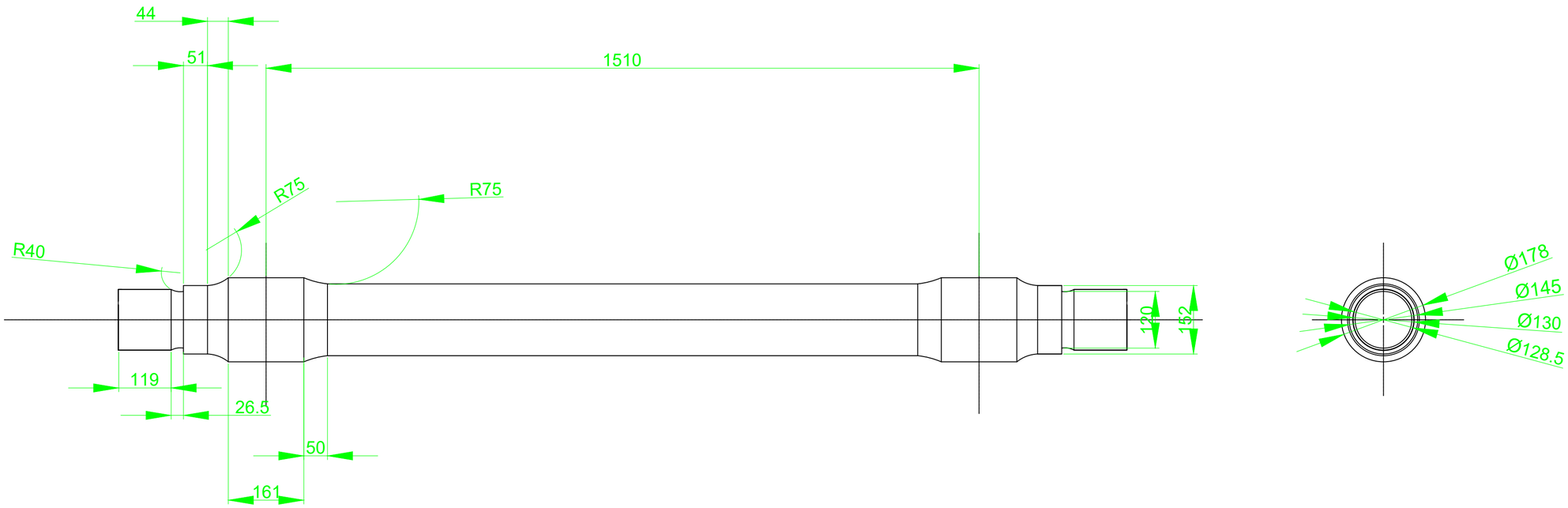
Parts List

Owner	MSD Group V8G		
Title of Sheet	Brake System Assembly		
	material	Quantity	Scale
			1:4
All Dimensions are in mm		Sheet no. -	5



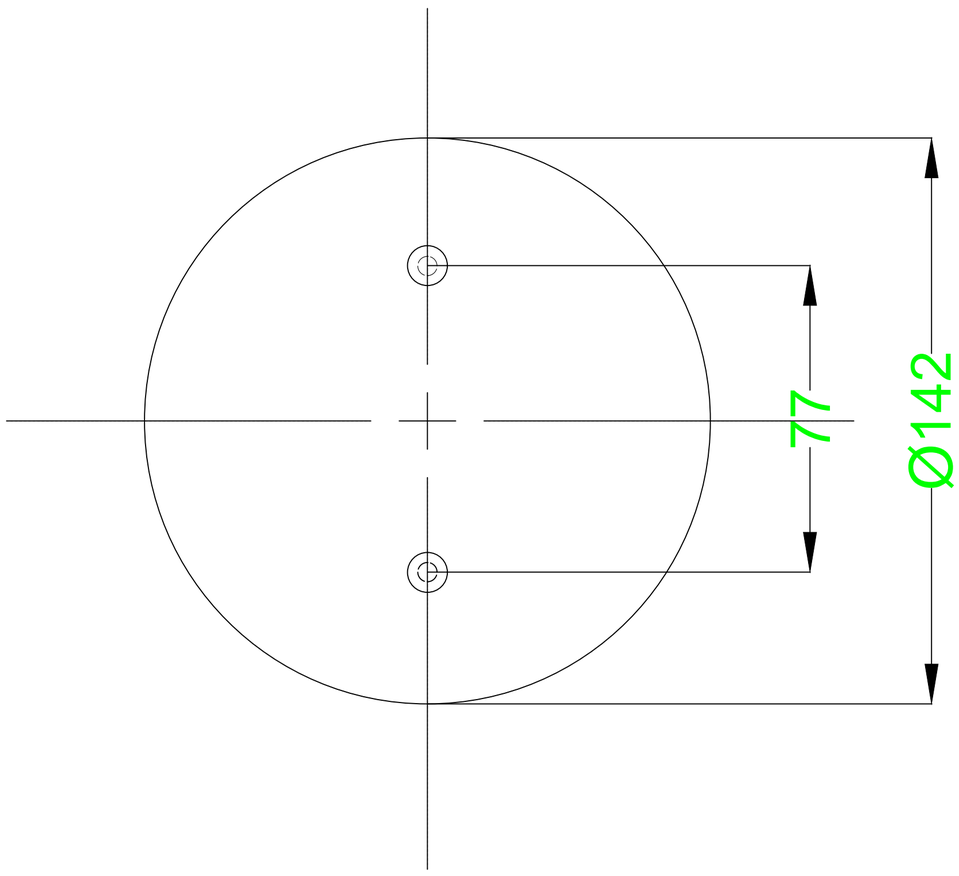
SHA007

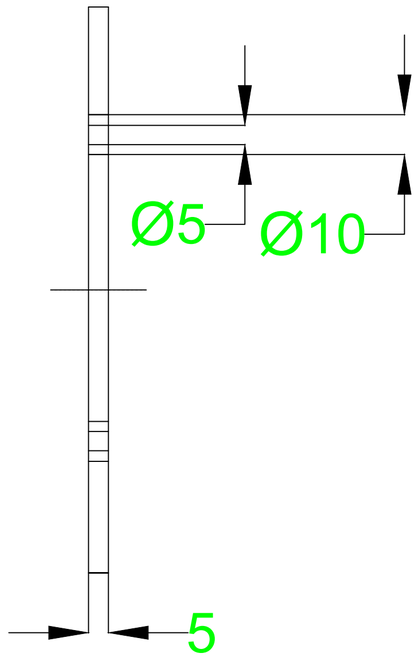
Owner	MSD Group V8G		
Title of Sheet	Hook		
		Quantity	Scale
			1:2
All Dimensions are in mm		Sheet no. - 6	



CWA003

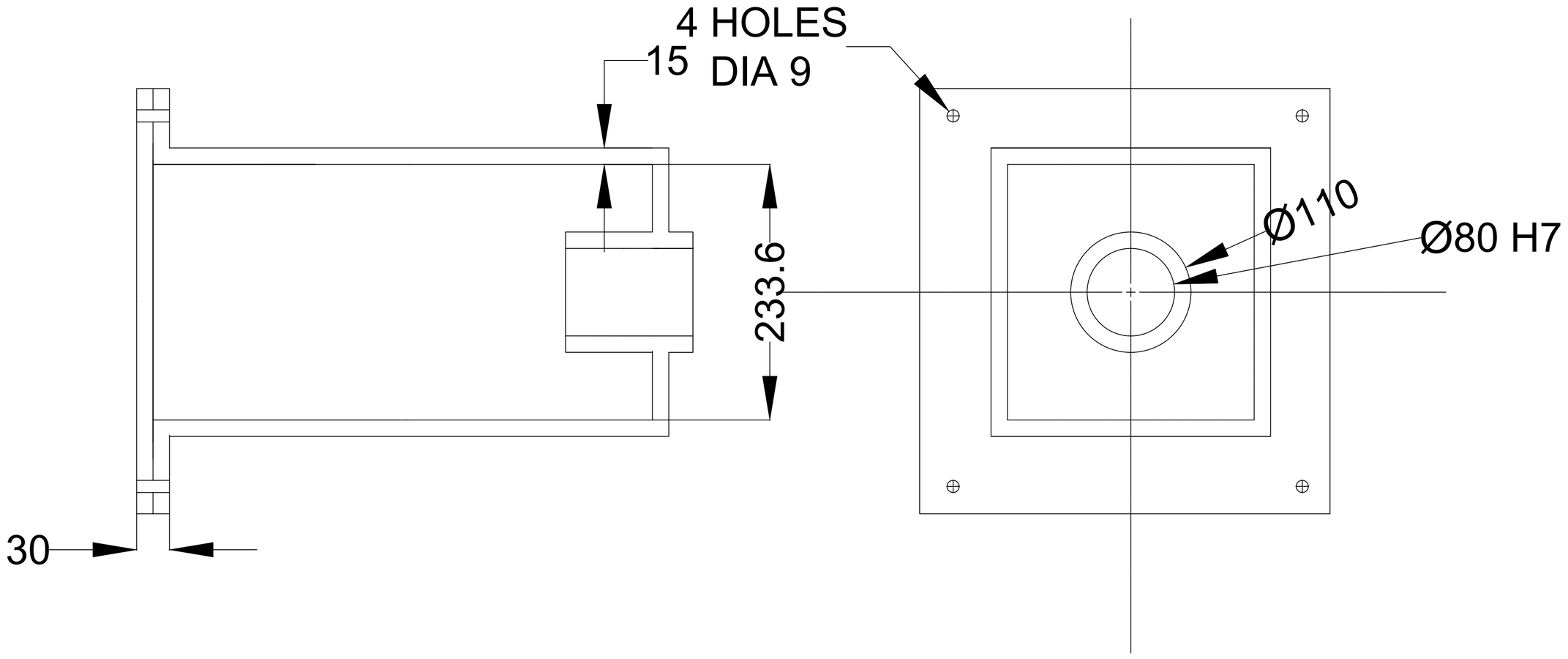
Owner	MSD Group V8G		
Title of Sheet	Axle component drawing		
		Quantity	Scale
			1:6.667
All Dimensions are in mm		Sheet no. - 7	





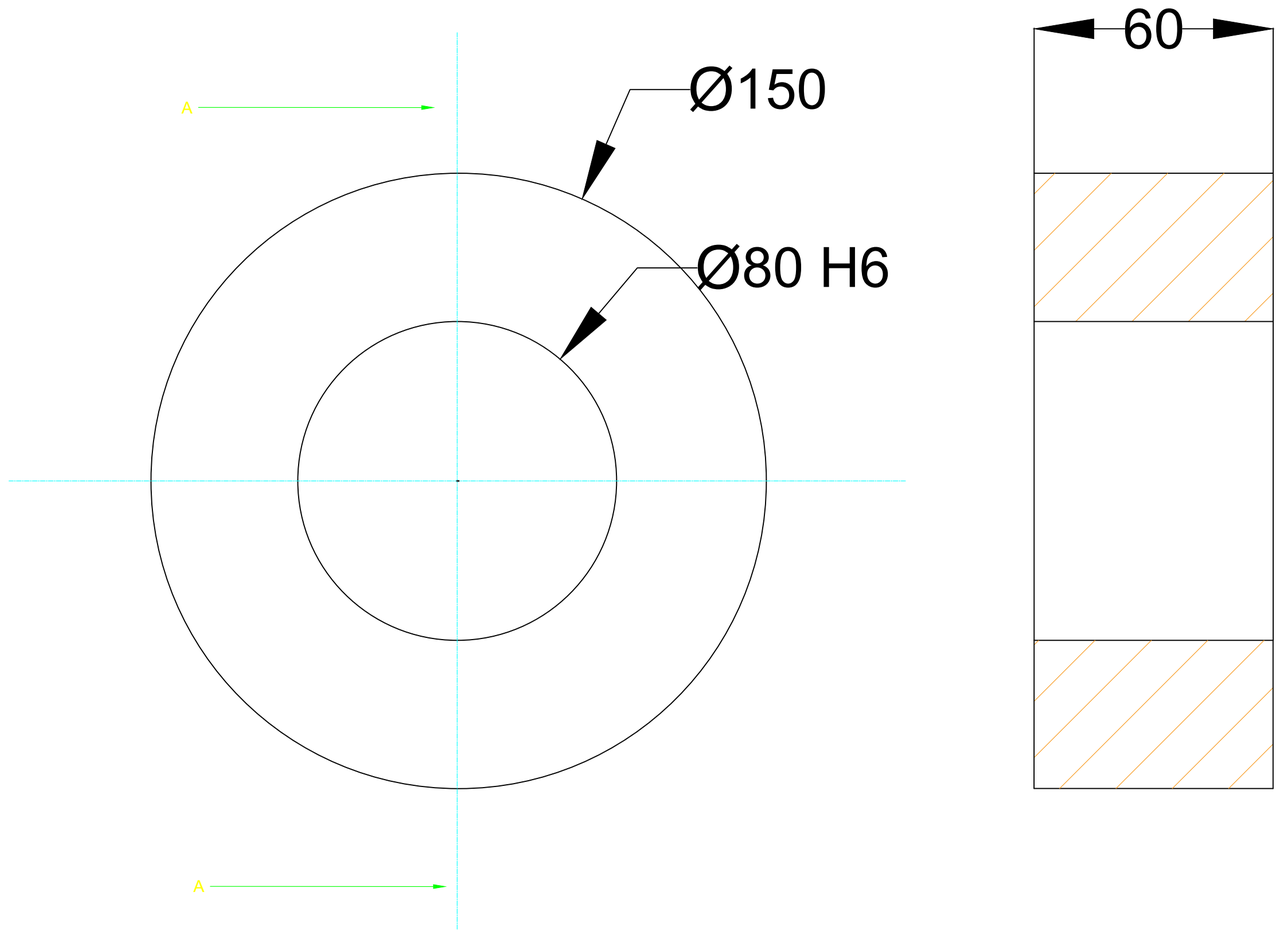
BHC003

Owner	MSD Group V8G		
Title of Sheet	Axle Cap		
		Quantity	Scale
			1:1
All Dimensions are in mm		Sheet no. - 8	



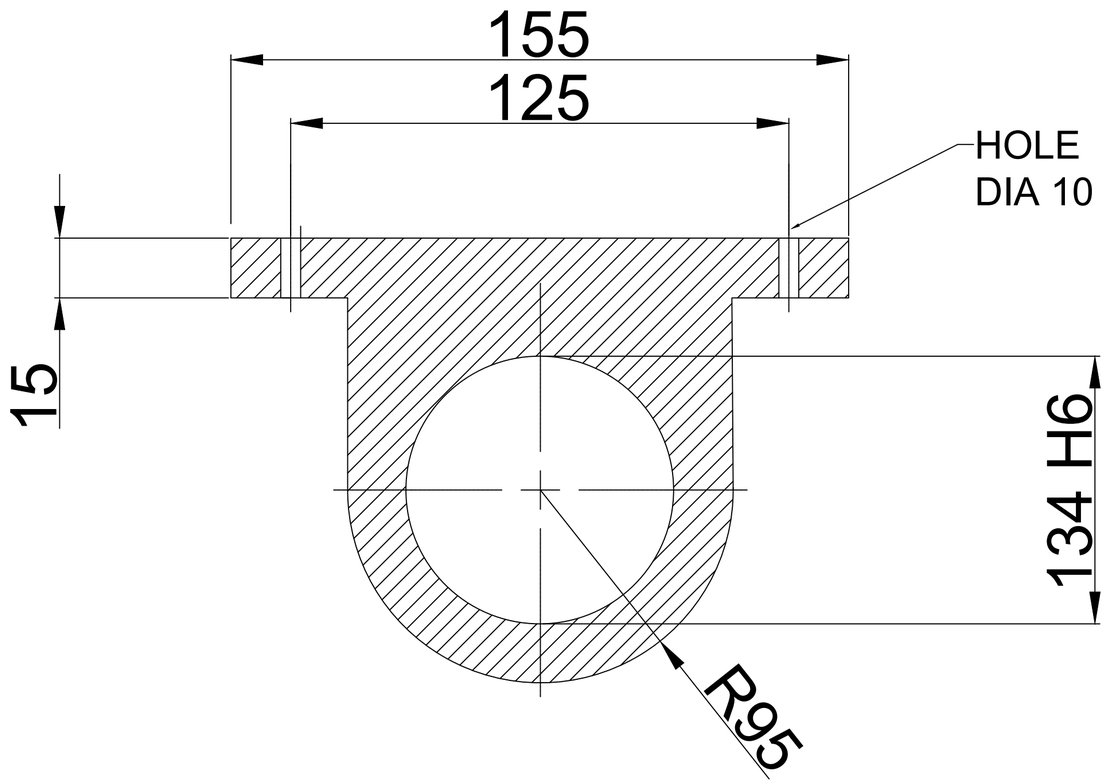
SHA001

Owner	MSD Group V8G		
Title of Sheet	Spring box		
		Quantity	Scale
			1:2
All Dimensions are in mm		Sheet no. - 9	



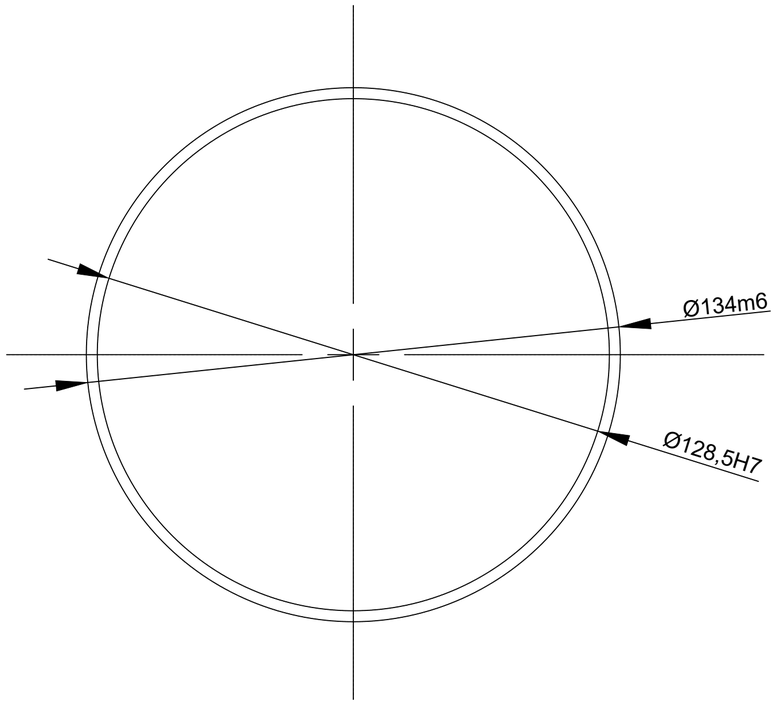
SHA009

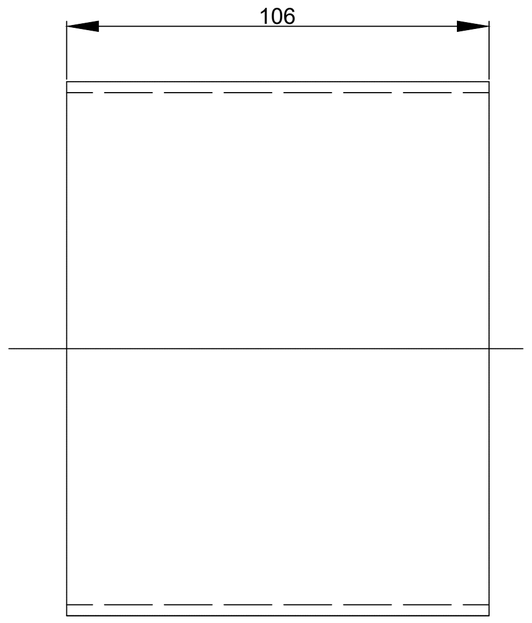
Owner	MSD Group V8G		
Title of Sheet	Bar collar		
		Quantity	Scale
			1:1
All Dimensions are in mm		Sheet no. - 10	



BHC002

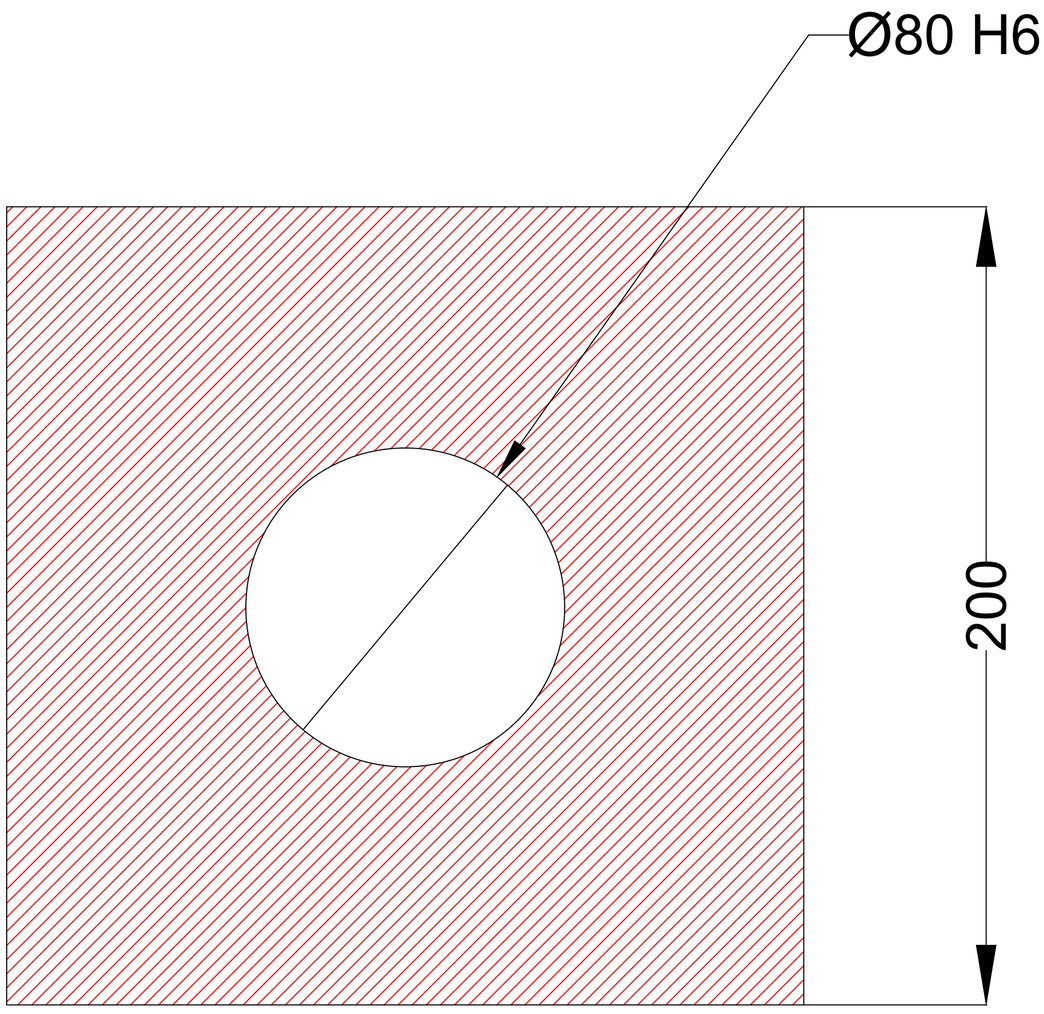
Owner	MSD Group V8G		
Title of Sheet	Bush housing		
		Quantity	Scale
			1:2
All Dimensions are in mm		Sheet no. - 5	

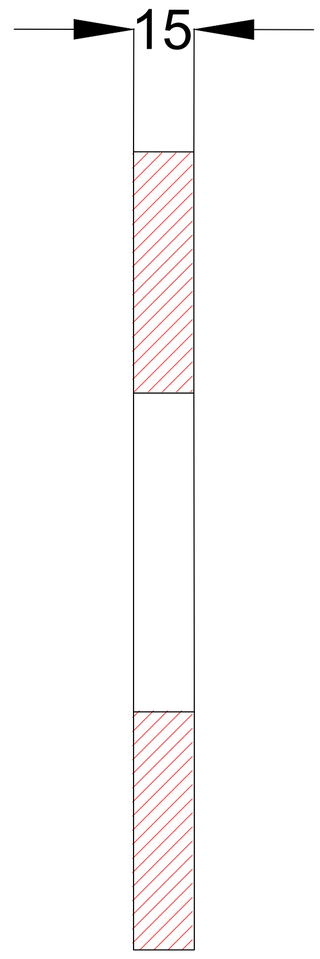




BHC001

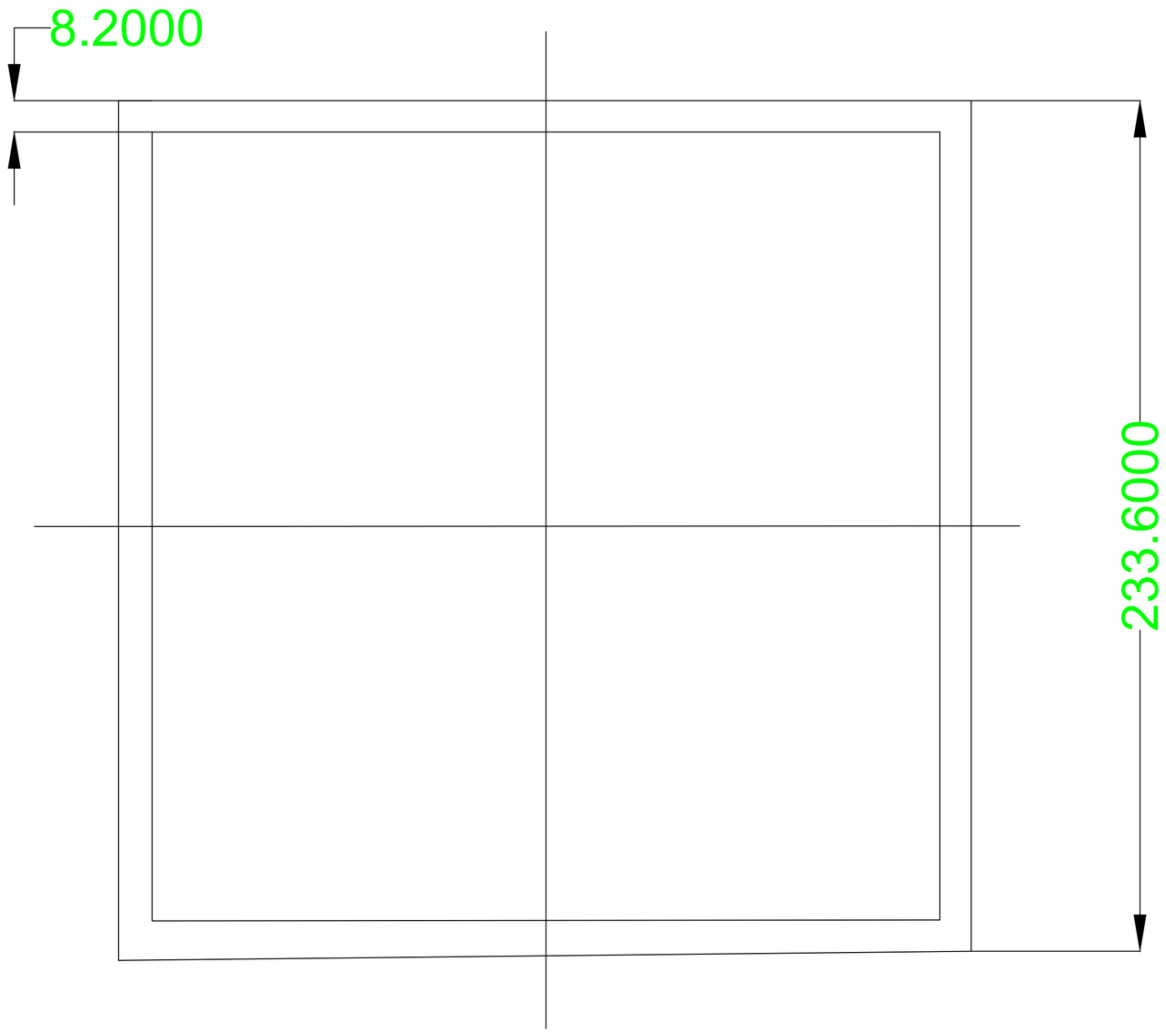
Owner	MSD Group V8G		
Title of Sheet	Bush		
		Quantity	Scale
			1:1
All Dimensions are in mm		Sheet no. - 5	





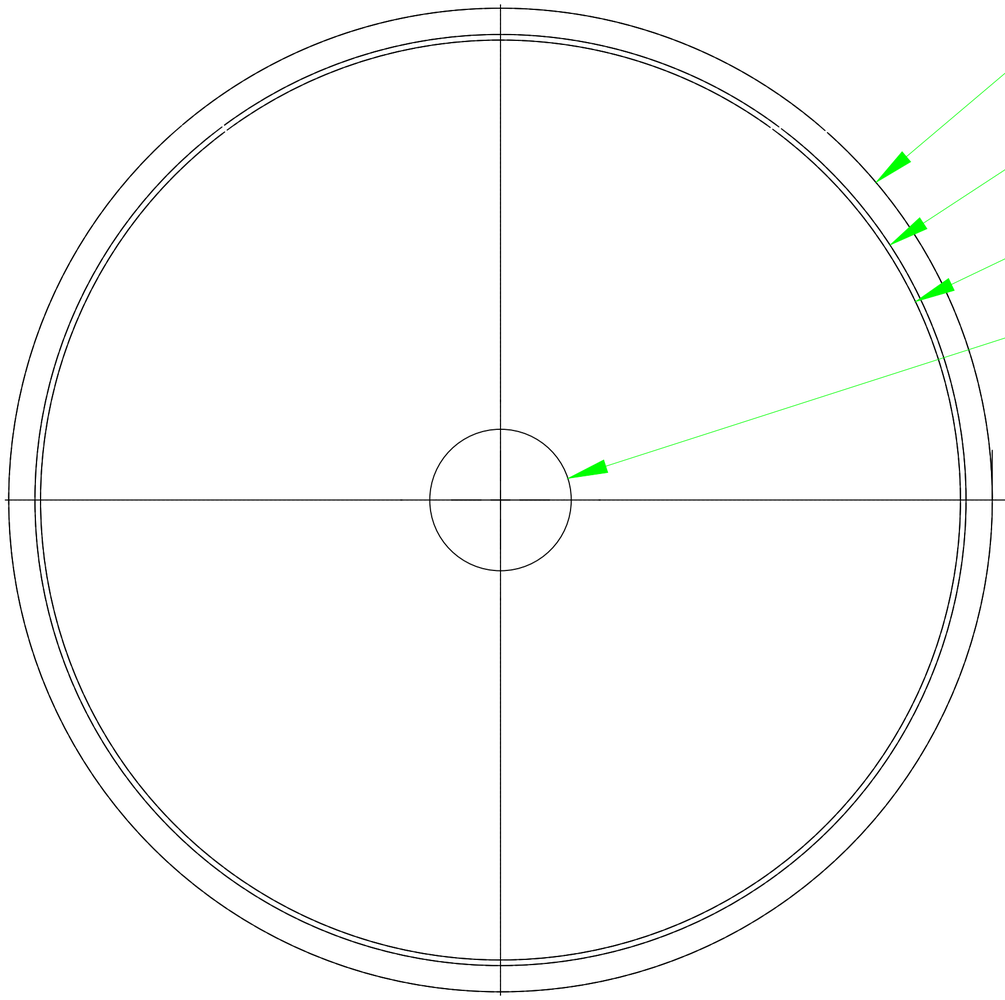
SHA005

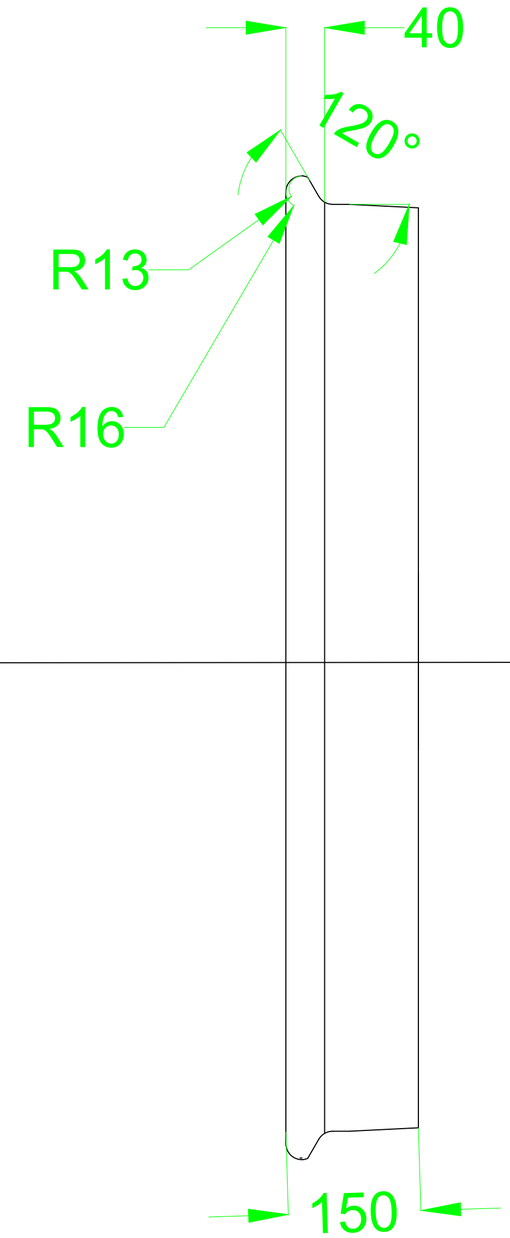
Owner	MSD Group V8G		
Title of Sheet	Collar		
		Quantity	Scale
			1:1
All Dimensions are in mm		Sheet no. - 3	



CWA002

Owner	MSD Group V8G		
Title of Sheet	Lateral Beam of Chassis		
		Quantity	Scale
			1:1
All Dimensions are in mm		Sheet no. - 5	



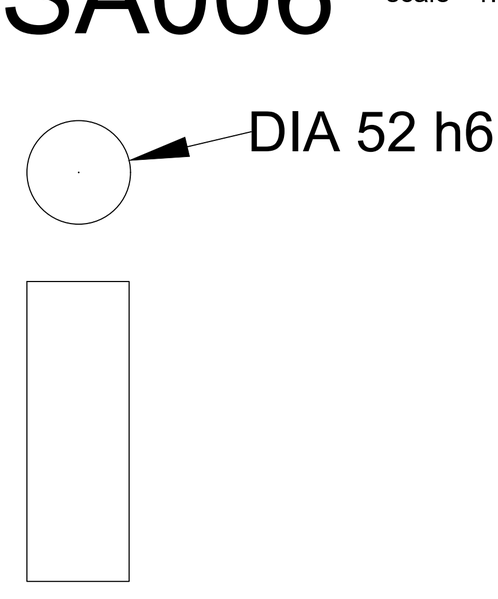


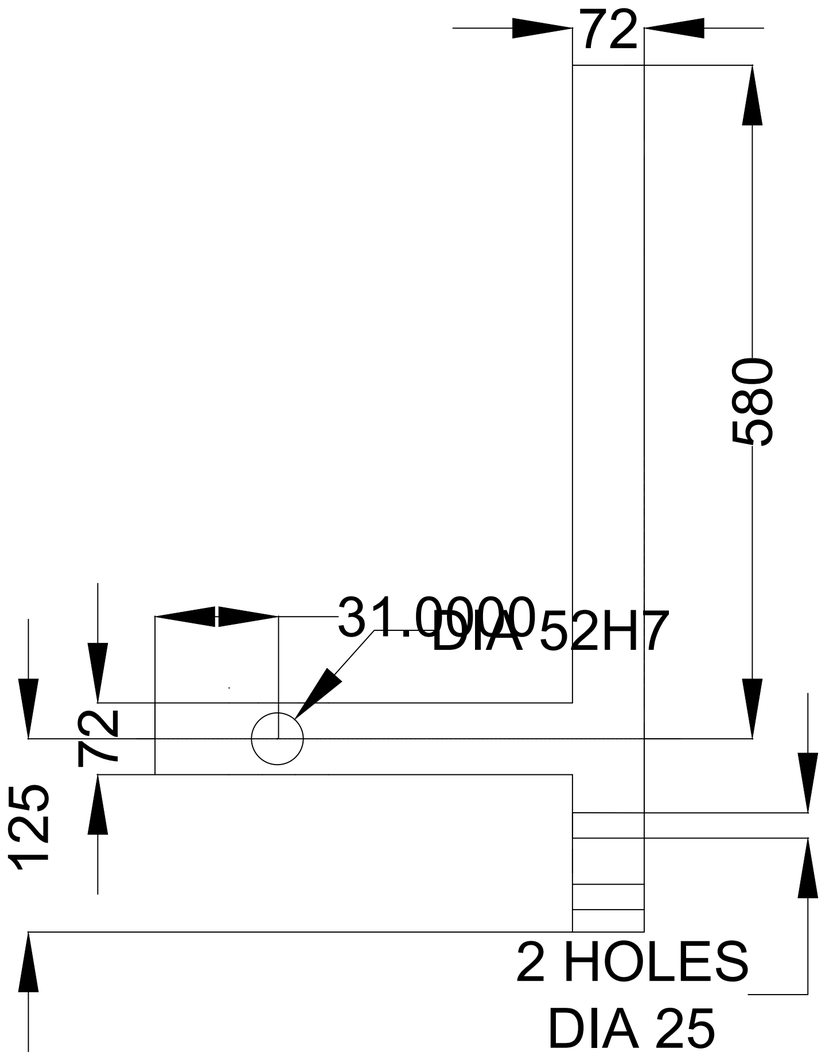
CWA004

Owner	MSD Group V8G		
Title of Sheet	Railway Wheel		
		Quantity	Scale
			1:4
All Dimensions are in mm		Sheet no. - 1	

BSA006

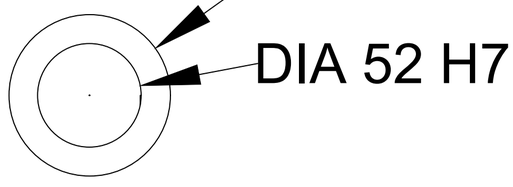
scale= 1:2





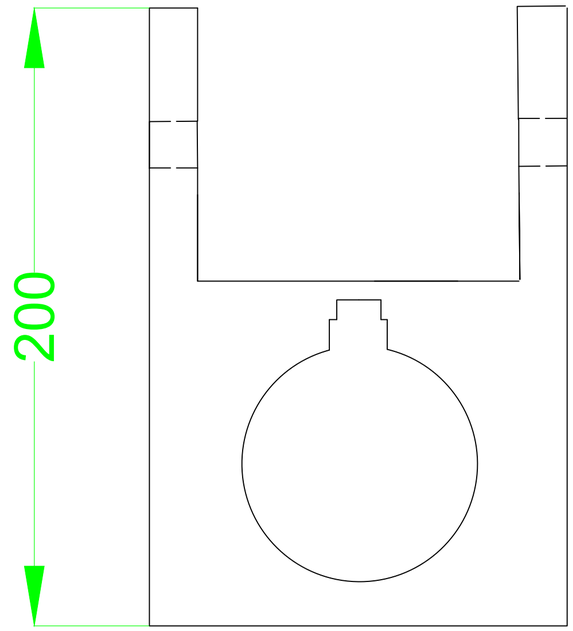
BSA007

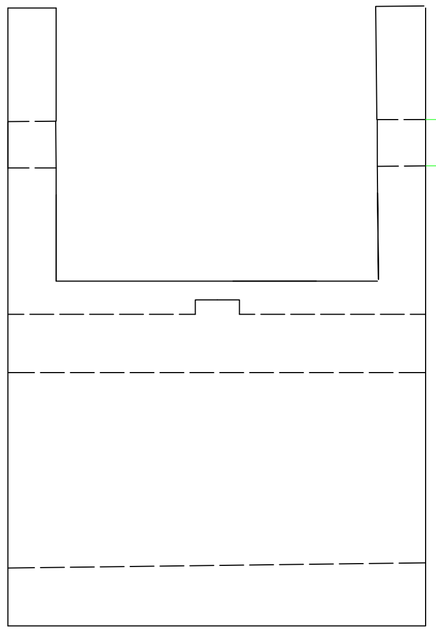
scale= 1:2

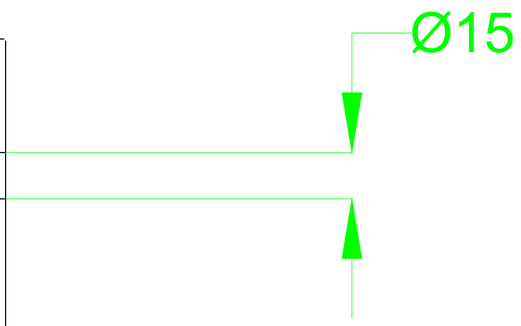


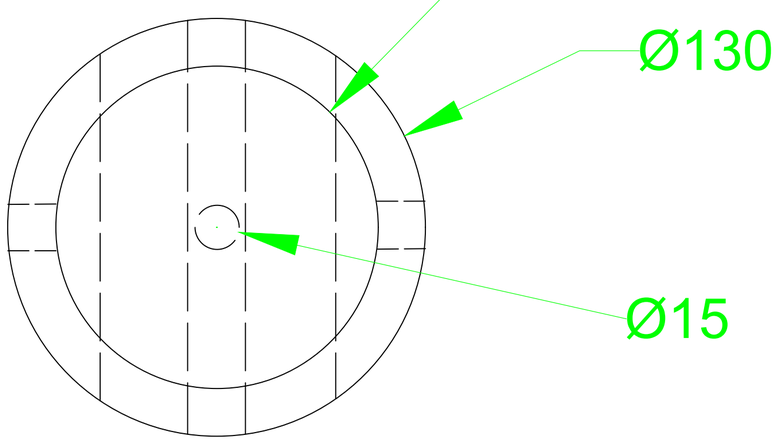
BSA001

Owner	MSD Group V8G		
Title of Sheet	Brake Lever and pin		
		Quantity	Scale
			1:4
All Dimensions are in mm		Sheet no. - 4	

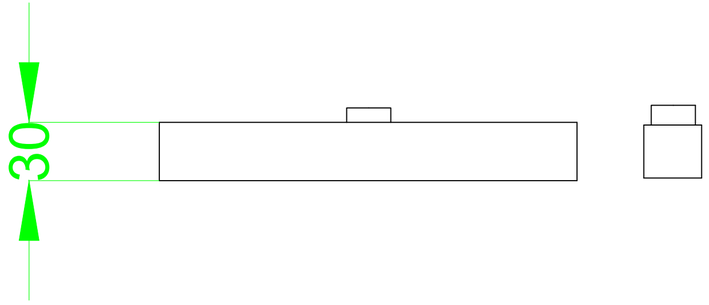








SHA008

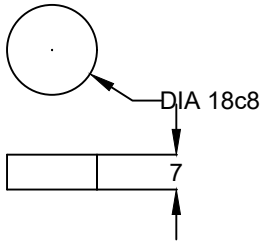


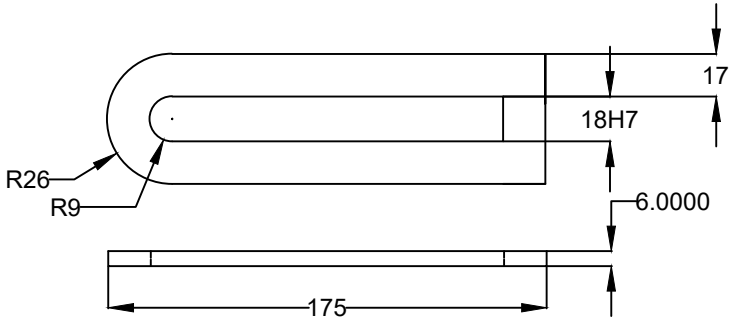
SHA010

Owner	MSD Group V8G		
Title of Sheet	Bar pocket		
	material	Quantity	Scale
			1:4
All Dimensions are in mm		Sheet no. - 2	

BSA003

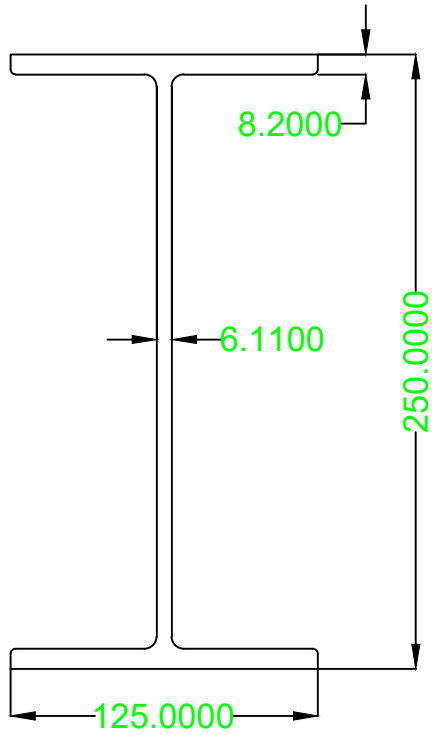
scale= 2:1





BSA002

Owner	MSD Group V8G		
Title of Sheet	Slider and slider pin		
		Quantity	Scale
			1:1
All Dimensions are in mm		Sheet no. - 4	

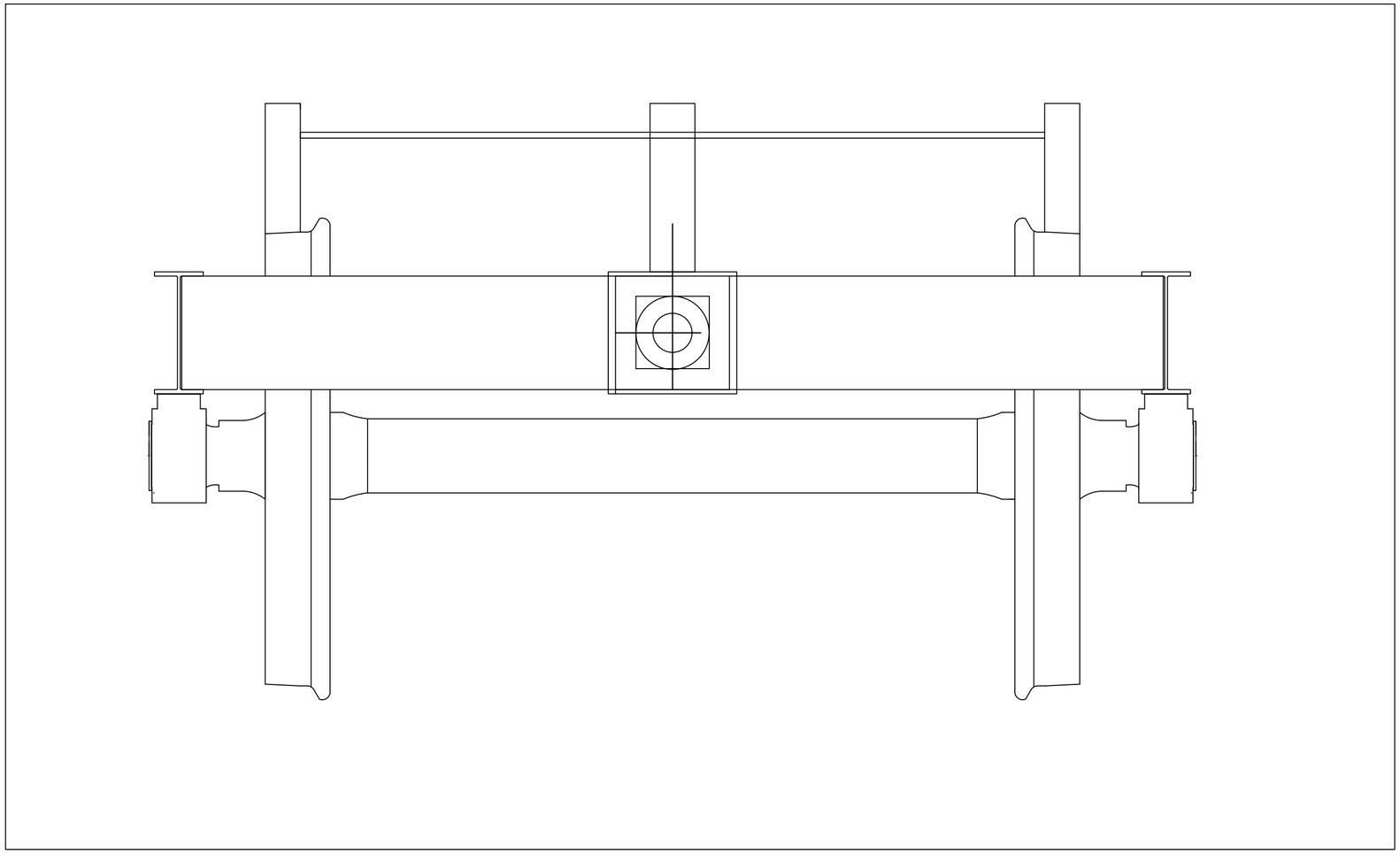


CWA001

Owner	MSD Group V8G		
Title of Sheet	Longitudinal Beam of Chassis		
		Quantity	Scale
			1:1
All Dimensions are in mm		Sheet no. - 4	

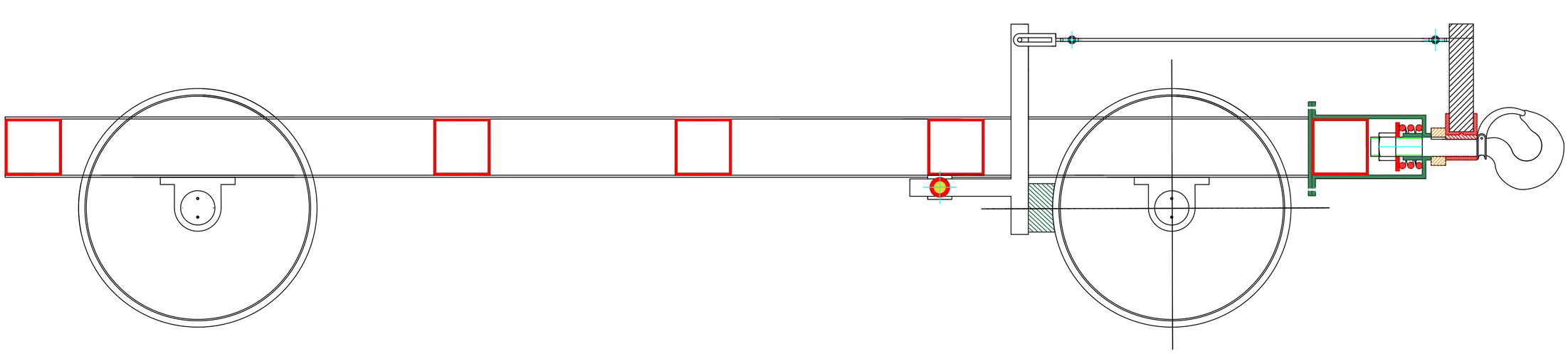
Final Assembly

Front View



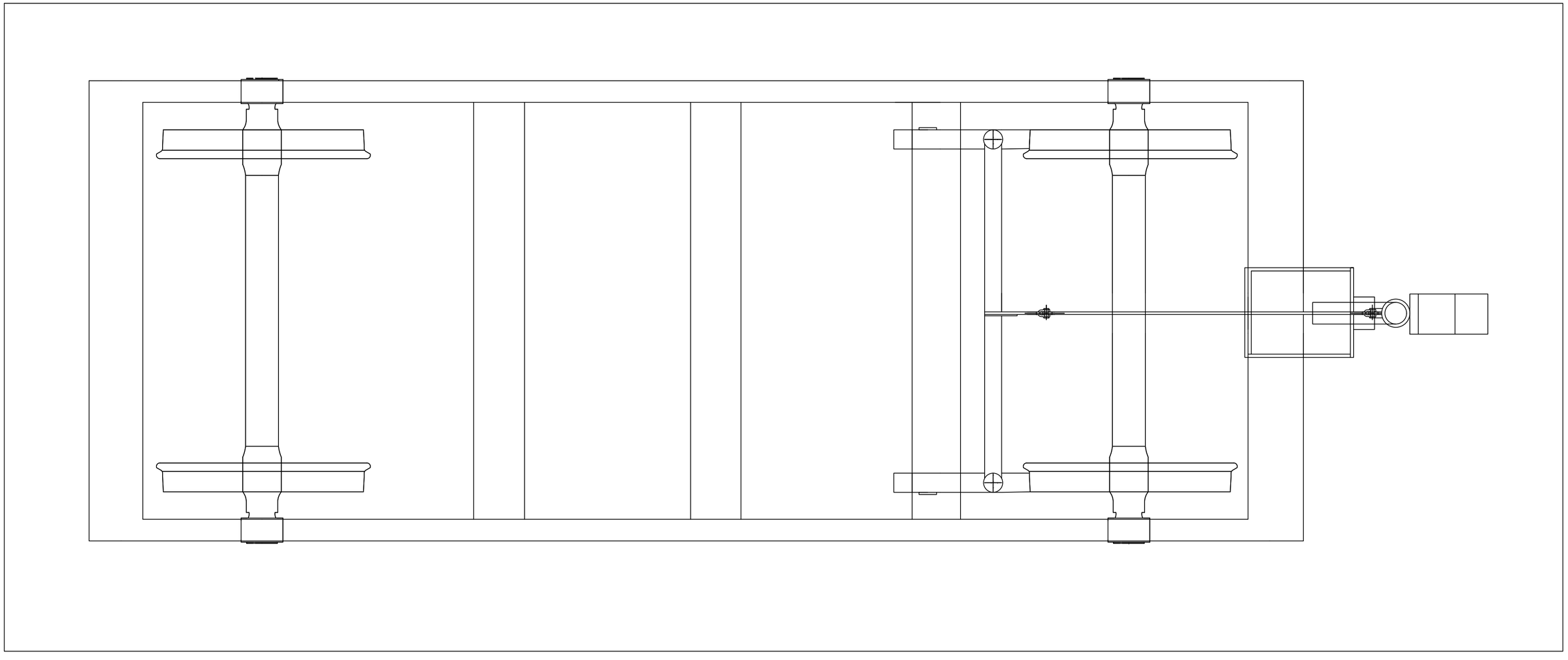
Final Assembly

Side View



Final Assembly

Top View



Specifications of the Machine

1. **Overall Dimensions:** (6.45*2.13*1.22) m^3

2. **Power Requirement:** 2537.5 W

3. **Operational Specifications:**
    - The cart maintains a velocity of 0.125 m/s
    - The stopping distance is 1 m
    - The cart is subjected to only linear motion