RADIO ASTRONOMY CENTRE
NATIONAL CENTRE FOR RADIO ASTROPHYSICS

RAC INTERNAL REPORT:
NCRA-OOTY/R300

DRIVE SHAFT PIPE REPLACEMENT PROCEDURE

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OBJECTIVE: To describe the Detailed new set of procedure for drive shaft pipe and stub Shaft replacement by using the developed pipe fit-up clamp

APPROVAL BLOCK		
APPROVALS	**TITLE**	**SIGNATURE**
PREPARED BY	**SRIRAM P**	
REVIEWED BY		
APPROVED BY		

Revision	Date	Modification/change
Ver 1	June 17, 2020	

SUMMARY

ORT (ooty Radio telescope) commissioned in the early of 1970 in 11.25 degree slope and 530 meter long. It includes total 4nos drive platforms, servo platform and 20nos non drive platform and each platform are connected with each other using 4 inch drive pipe shaft

Main intension of this document preparation is to describe the step by step procedure to be followed for drive shaft pipe and stub shaft replacement by using developed pipe fit up clamp. This document is also having the complete details of drive pipe shaft and various mechanical components like coupling, bearing, stub shaft with accurate dimension and details of the connection between the mechanical components in single document

This document contains the each components two dimensional drawing with 1:1 scale ratio with tolerance limit. Software used for two dimensional drawing designs - AutoCAD 2010

TABLE OF CONTENTS

I. ORT -OVERVIEW

ORT telescope is inclined at 11.25 degree in north – south direction .Its cut section is cylindrical parabola. It is 530M long and 30M wide. There are 24nos parabolic frames mounted on "A" frame vertical supporting structure at 23M gap.

There is two operating speed in ORT,

A) SLEW SPEED:

There is 4nos slew motor having 12.5HP, 1450RPM which is installed in N10, N4, S4, and S10 Platform. Motor is directly connected with 1:9.6 ratio Gear box .By using flexible coupling. Gear box output shaft is connected with main drive pipe shaft by using chain drive having teeth ratio 1:2 .the speed of drive pipe shaft in slew mode is 75.52RPM

B) TRACK SPEED:

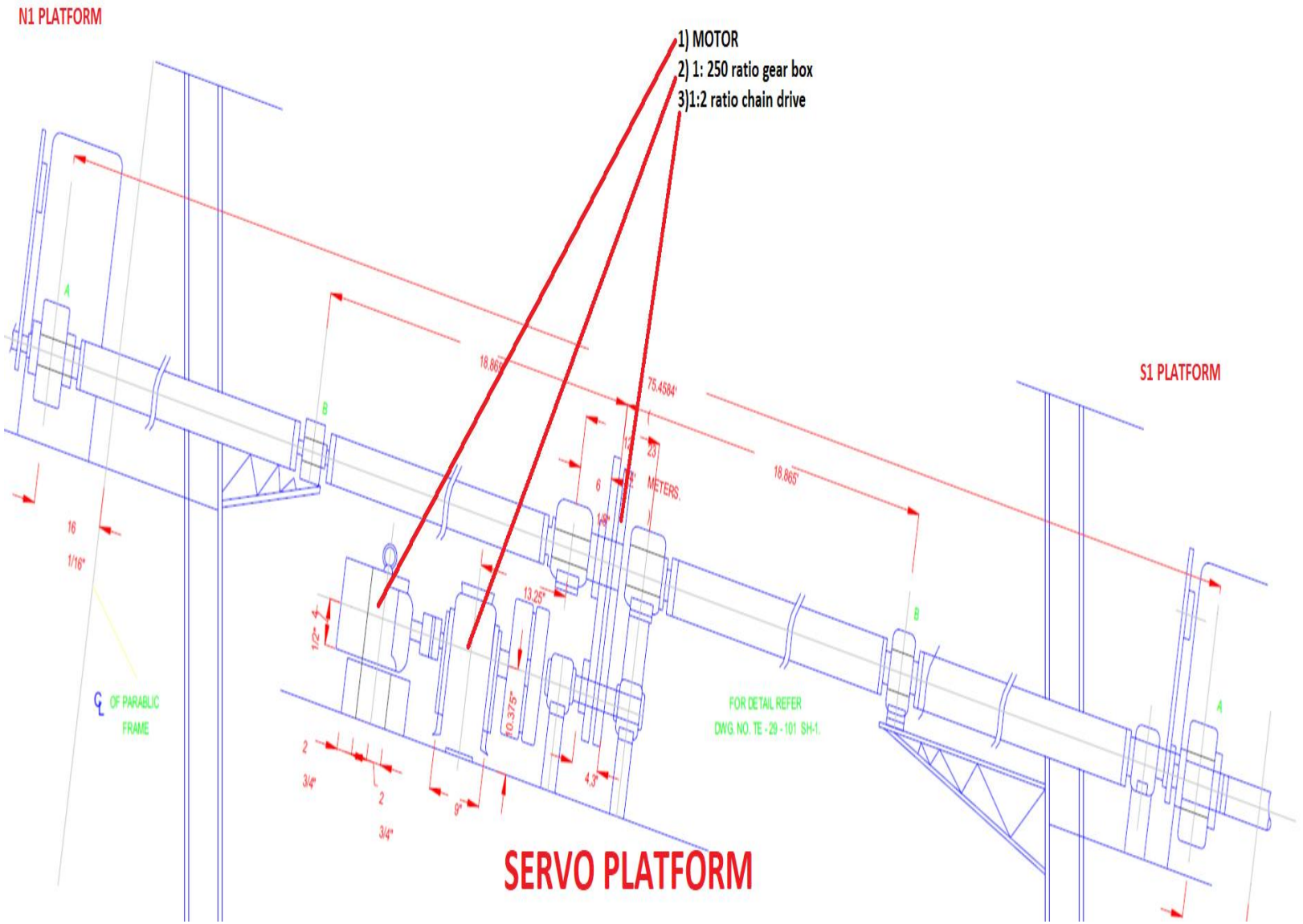
Track motor which is having 2HP power and 1500RPM output, installed in between S1 and N1 platform, it is called Servo platform. Servo motor is directly coupled with 1: 250 ratio Gear box. Gear box output shaft is connected with main drive pipe shaft by using chain drive having teeth ratio 1:2. The speed of drive pipe shaft in track mode is 3RPM.

All drive platforms (N4, N10, S4, S10) and all Non drive platform (other than N4, N10, S4,S10) are having 1:36 Gearbox which is connected with drive pipe shaft by using duplex chain drive system having teeth ratio 1:3. Pinion is mounted on the 1:36 gearbox output shaft and pinion is driving the bull gear which is installed in the parabolic structure circumference. Gear ratio of pinion to bull gear is 1:40.

Parabolic structure RPM in track mode = 1500/(250x2x3x36x40) = 0.00069444 RPM

Parabolic structure RPM in Slew mode = 1450/(9.6x2x3x36x40) = 0.01748167 RPM

All Platforms are interconnected by using 4" drive pipe shaft with various type couplings with bearings. Interconnections between all drive platforms are same except N11&N12, S11&S12, and S1&N1


N1 PLATFORM
1] MOTOR
2] 1: 250 ratio gear box
3]1:2 ratio chain drive
S1 PLATFORM
18.865'
75.4584'
18.865'
23'
METERS.
16
1/16"
13.25"
10.375"
4.3"
9"
2
3/4"
2
3/4"
1/2"
4
A
B
B
A
℄ OF PARABLIC
FRAME
FOR DETAIL REFER
DWG. NO. TE - 29 - 101 SH-1.
SERVO PLATFORM

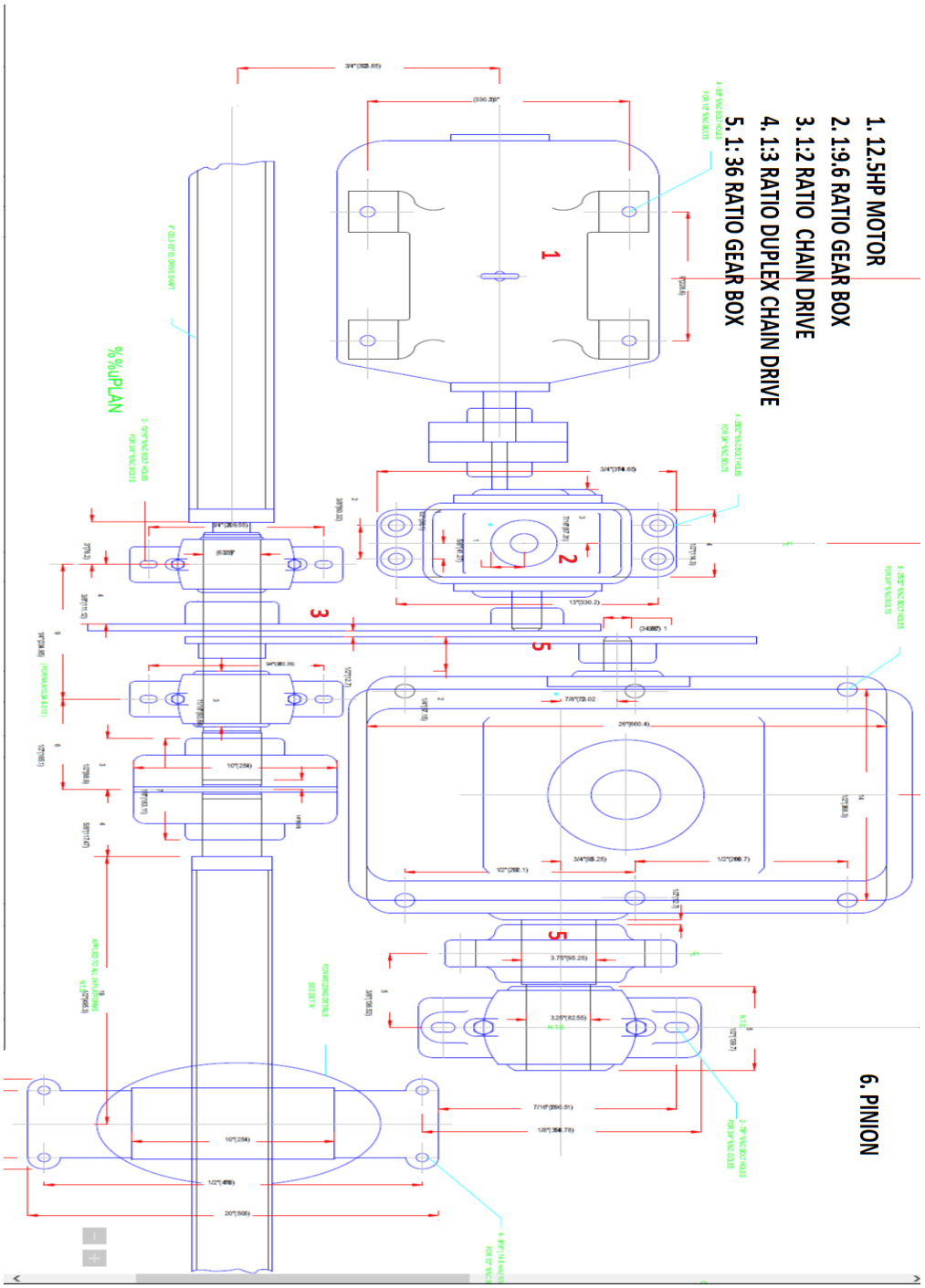
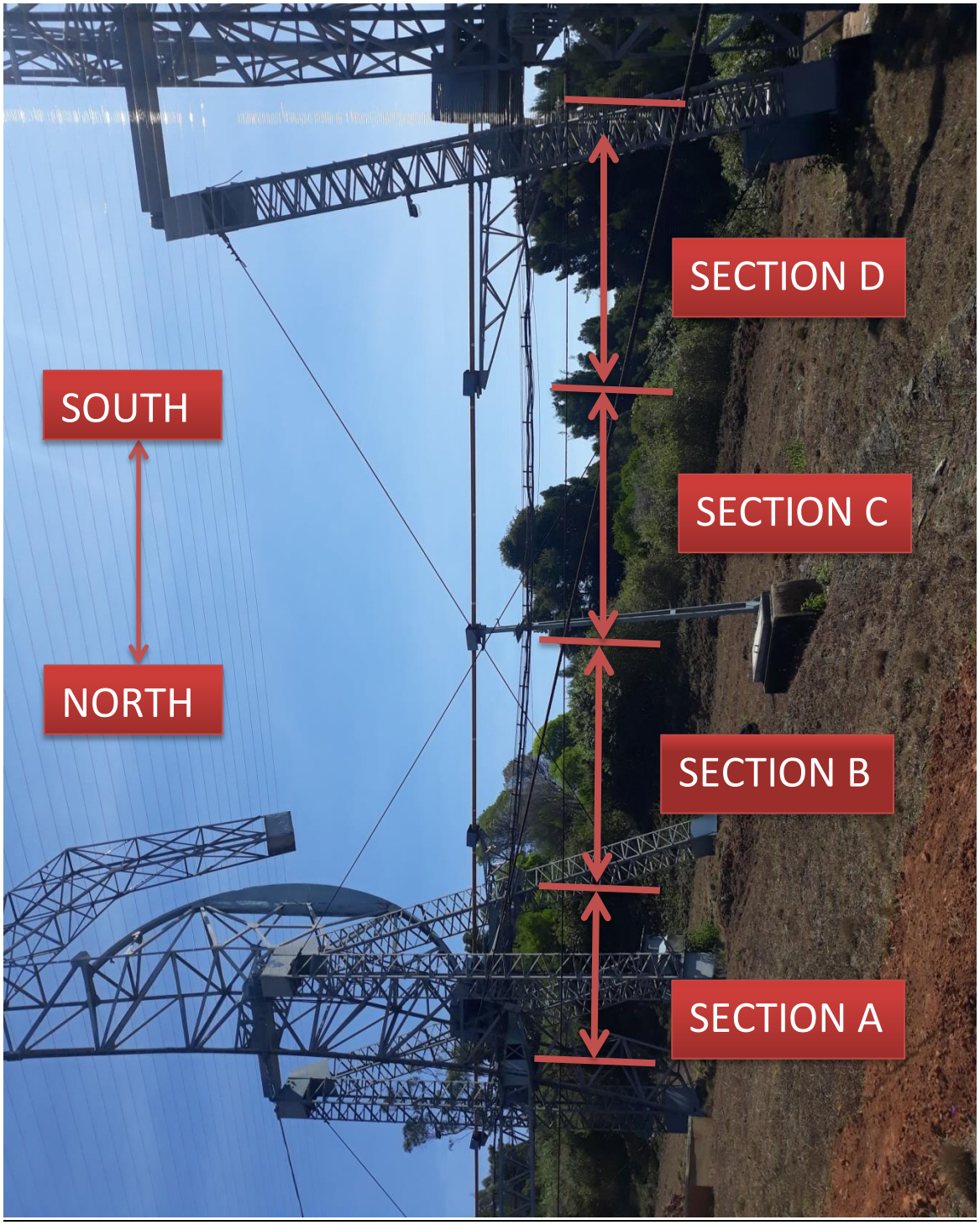
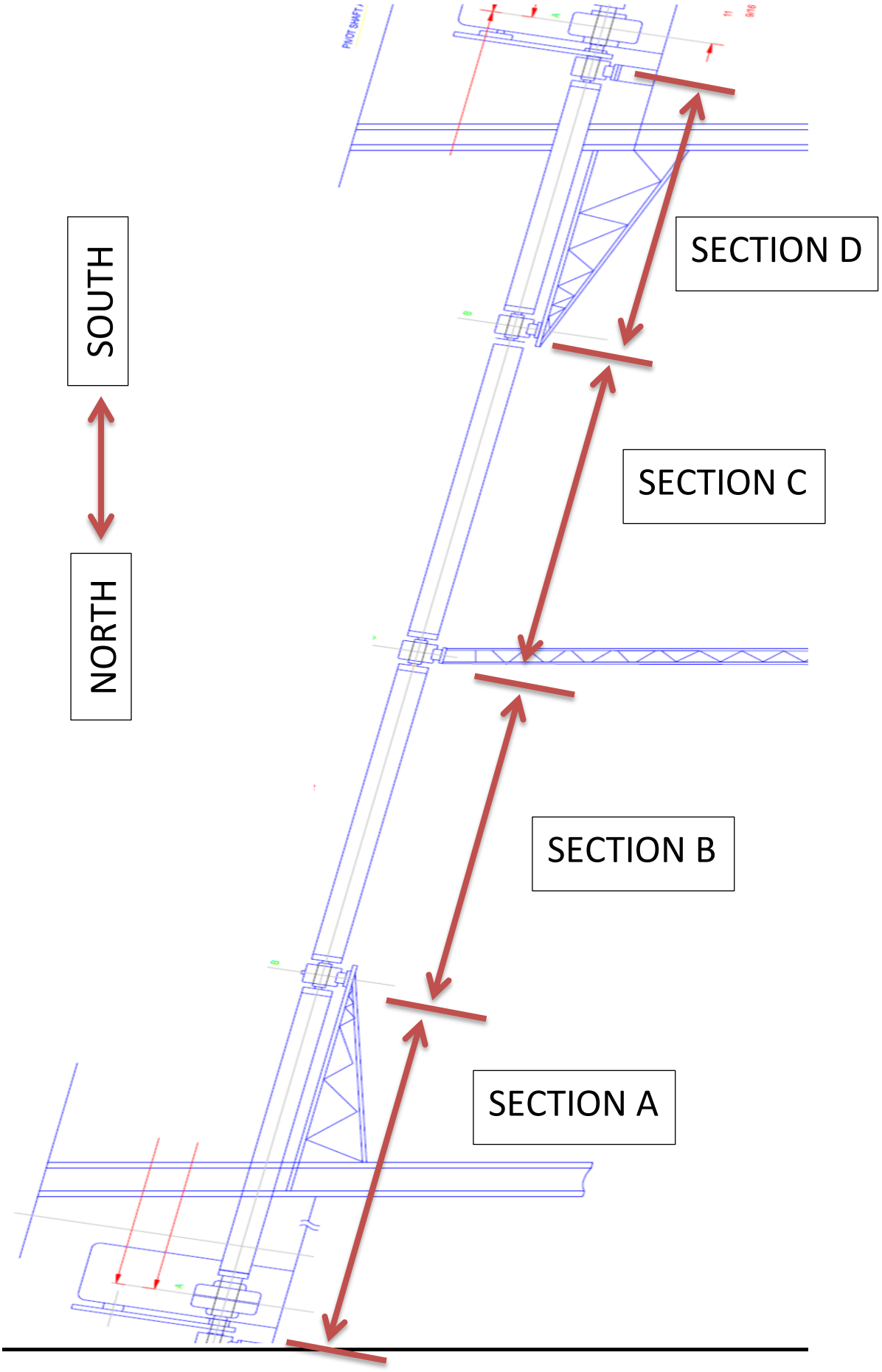


FIGURE : (N4,N10,S4,S10 PLATFORM)

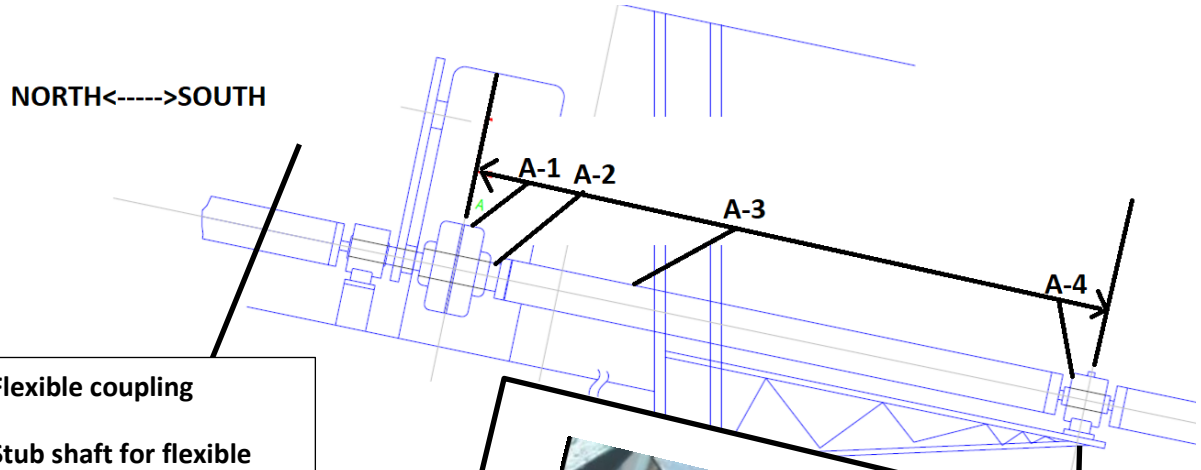
II INTERCONNECTION DETAILS

Interconnection System between platforms except S11&S12,N11&N12,S1&N1:




SOUTH
NORTH
SECTION D
SECTION C
SECTION B
SECTION A

SECTION A

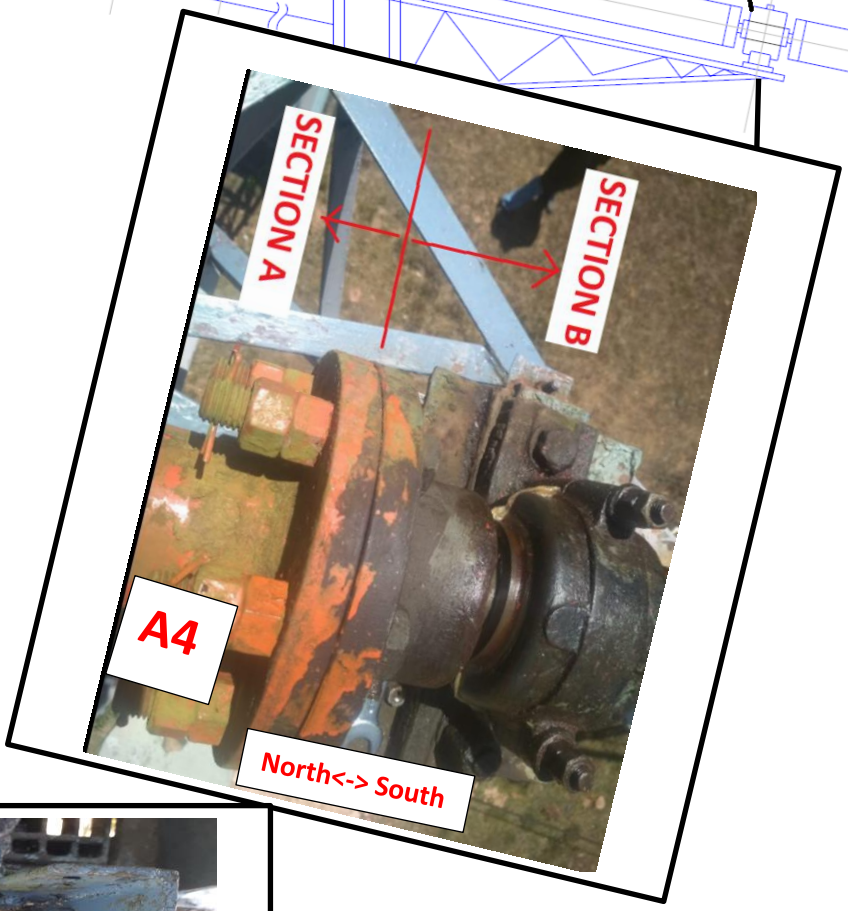


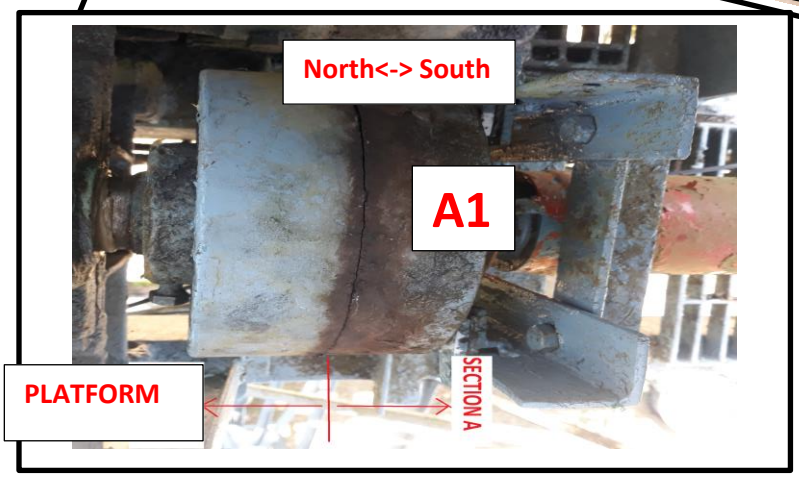
A-1) Flexible coupling

A-2) Stub shaft for flexible coupling

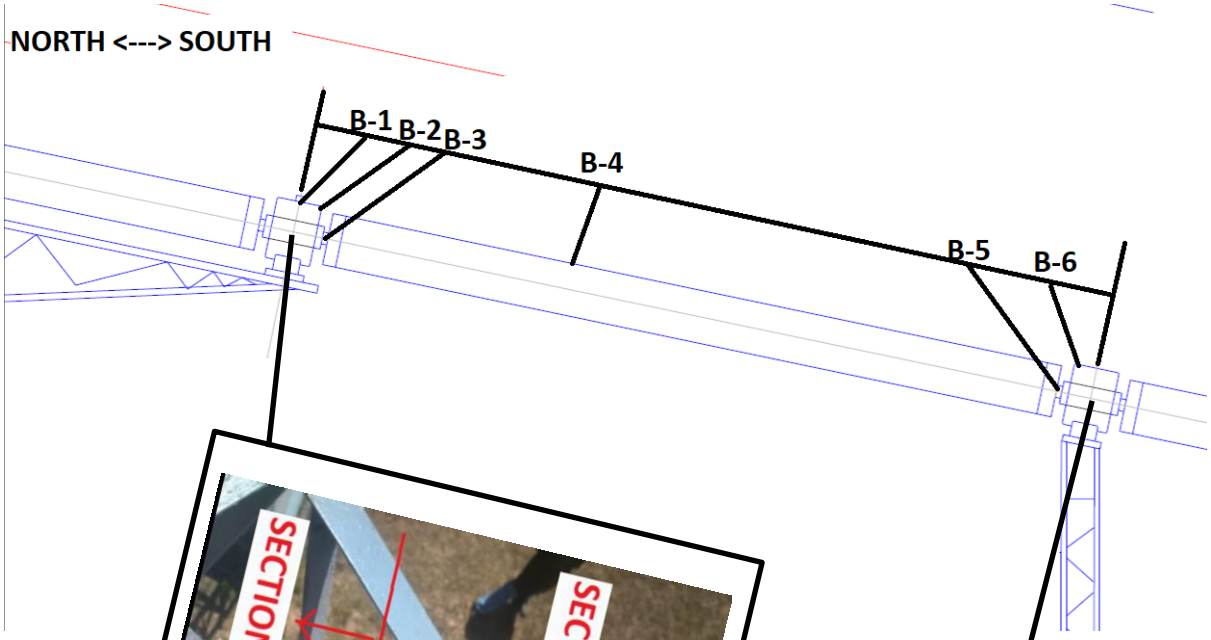
A-3) Drive pipe shaft

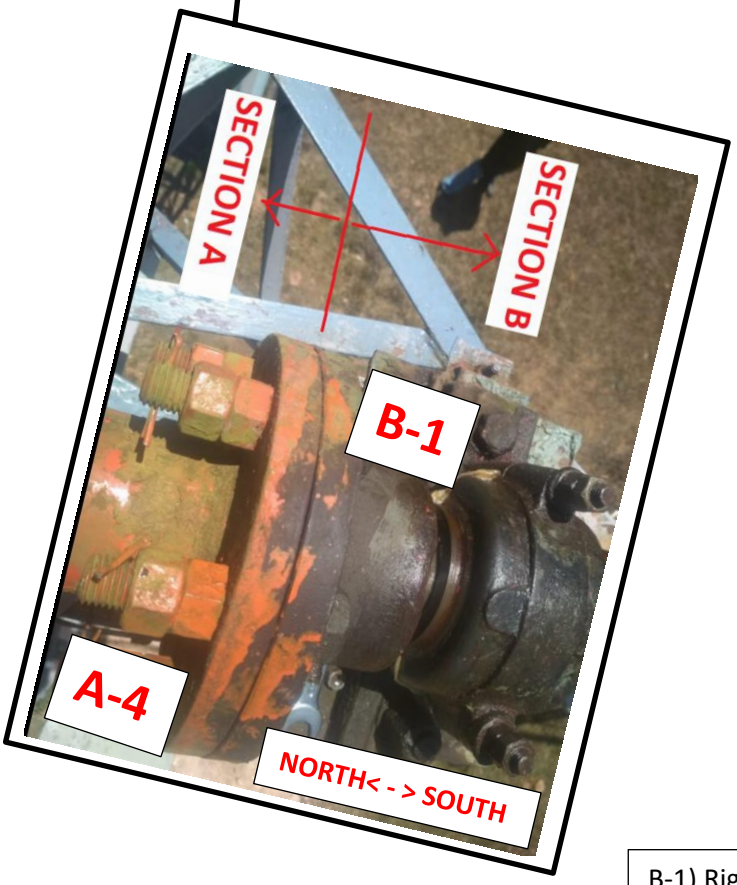
A-4) Rigid Coupling

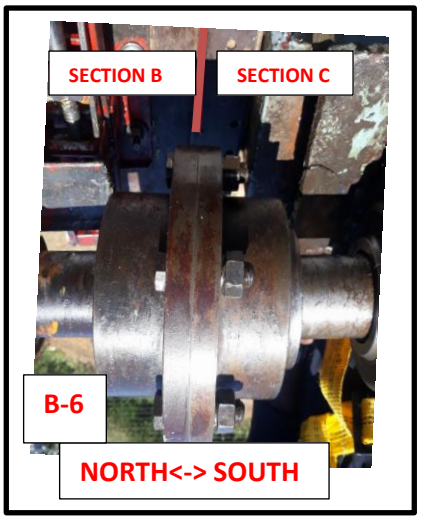




SECTION B







B-1) Rigid Coupling

B-2) Stub shaft for Rigid Coupling

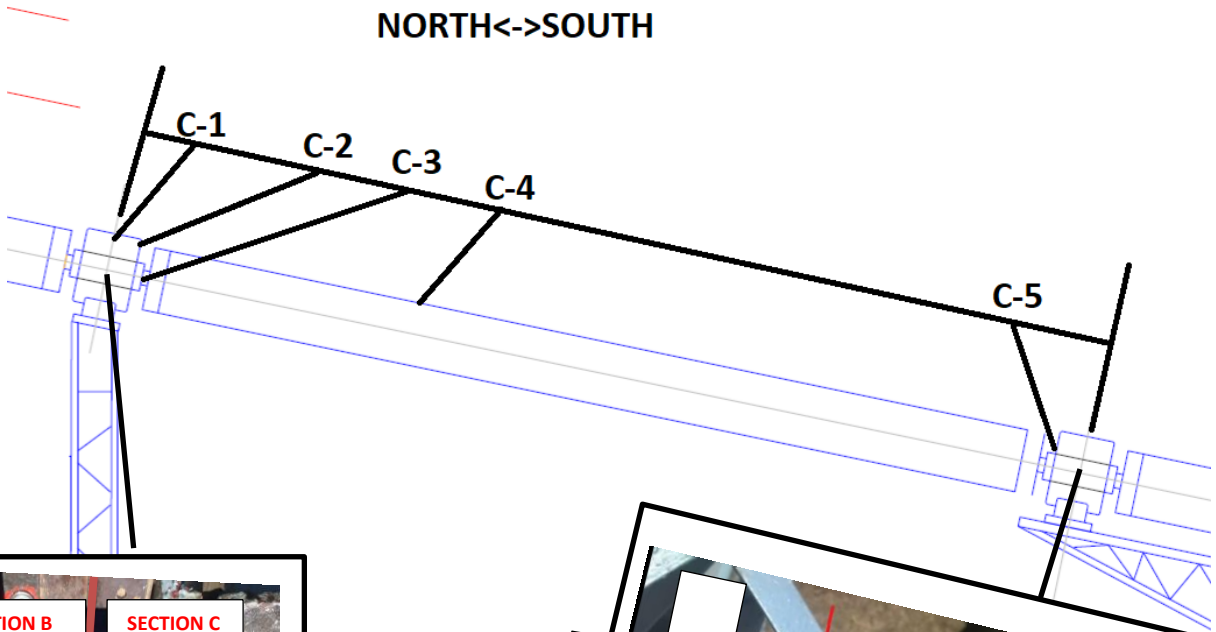
B-3) Self aligning Ball bearings

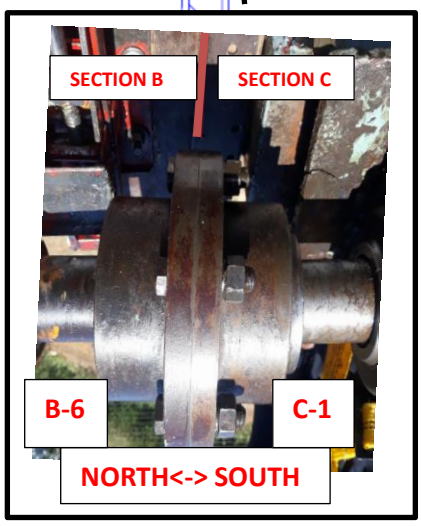
B-4) Drive Pipe Shaft

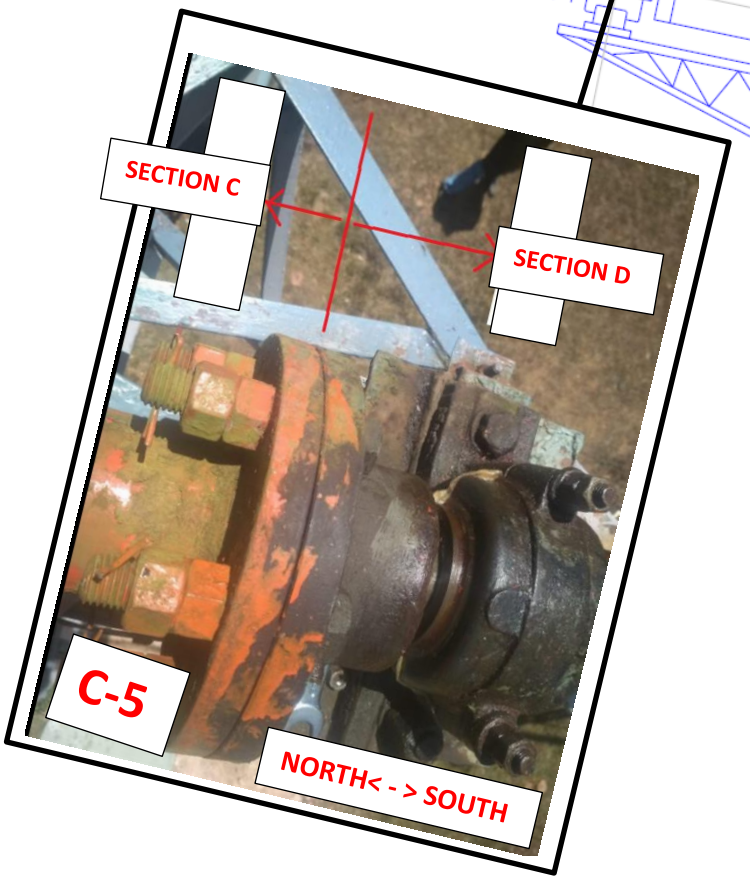
B-5) Stub shaft for Gear coupling – north side

B-6) Gear Coupling

SECTION C







C-1) Gear Coupling

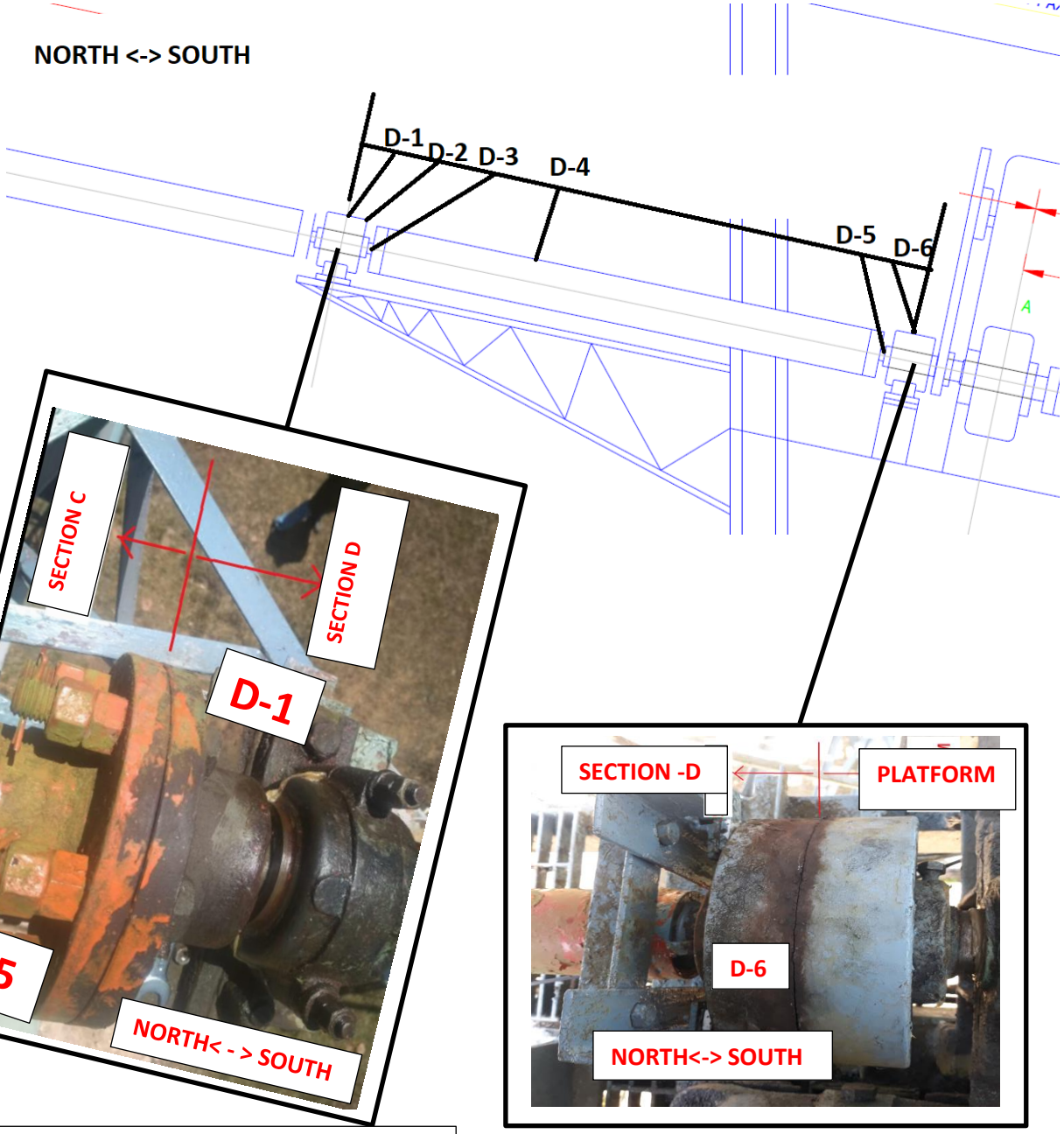
C-2) Stub shaft Gear coupling south side

C-3) Self Aligning Ball bearings

C-4) Drive Pipe shaft

C-5) Rigid Coupling

SECTION D



D-1) Rigid Coupling

D-2) Stub shaft for Rigid Coupling

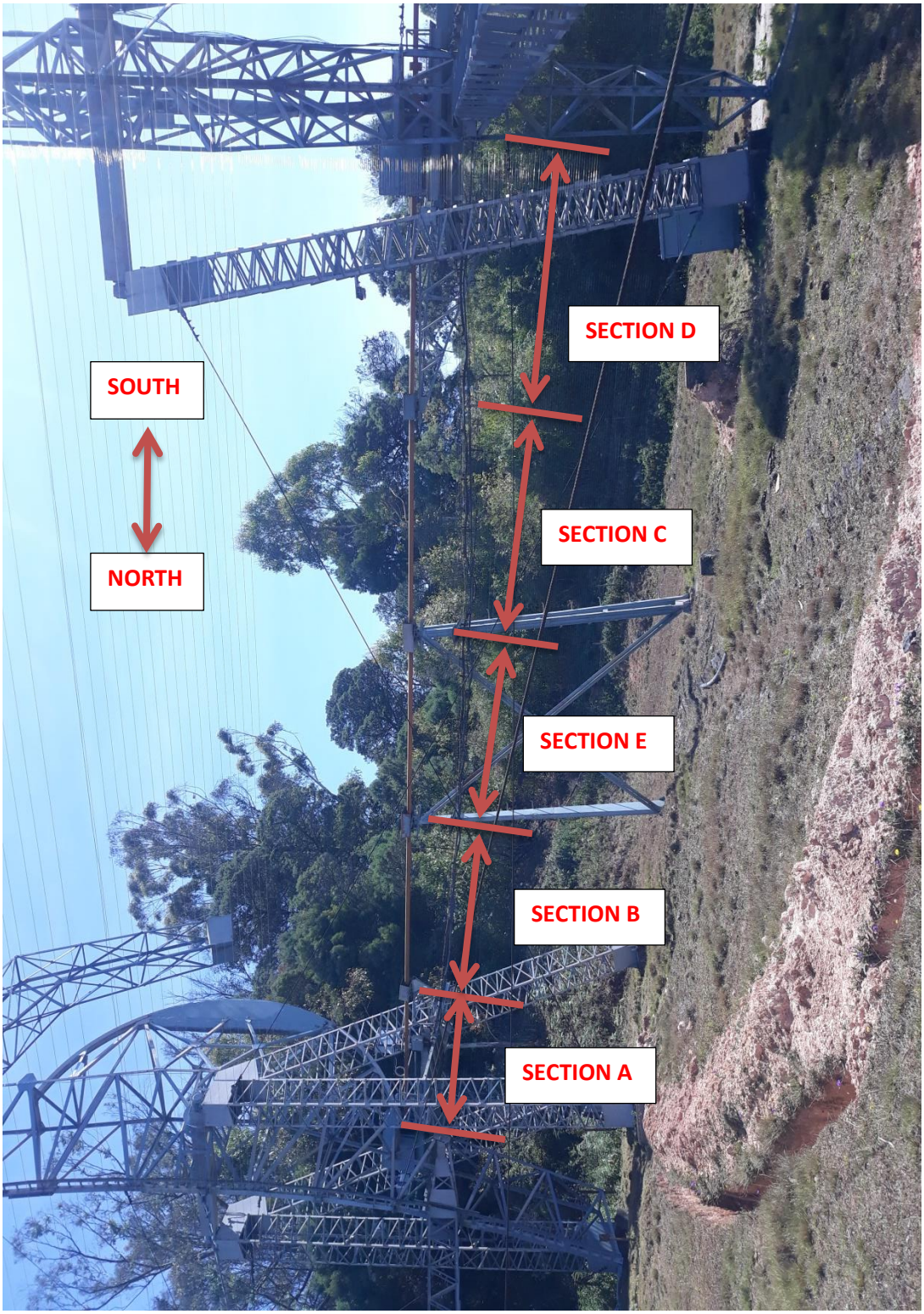
D-3) Self aligning Ball Bearings

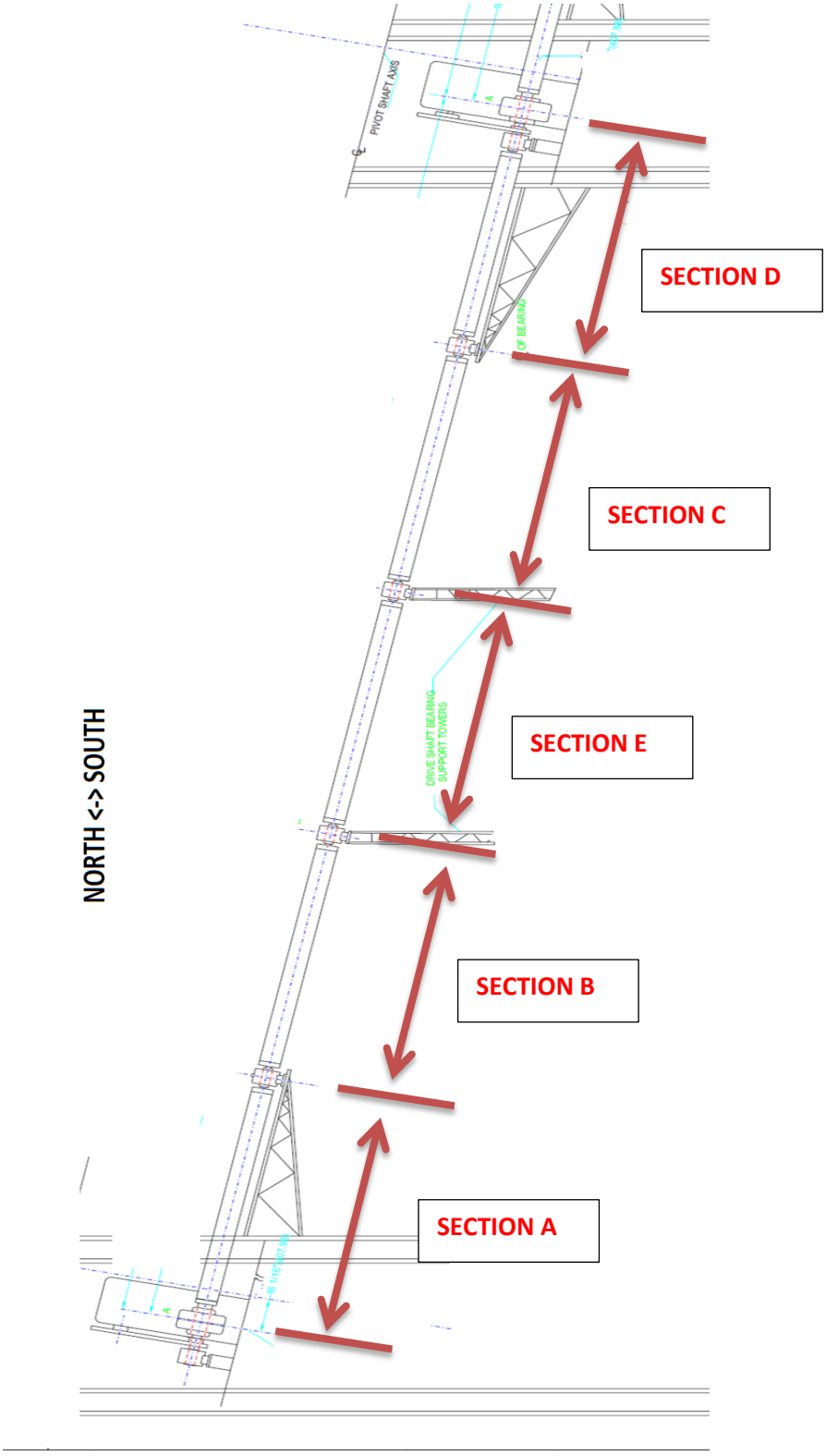
D-4) Drive Pipe shaft

D-5) Stub shaft for Flexible Coupling

D-6) Flexible Coupling

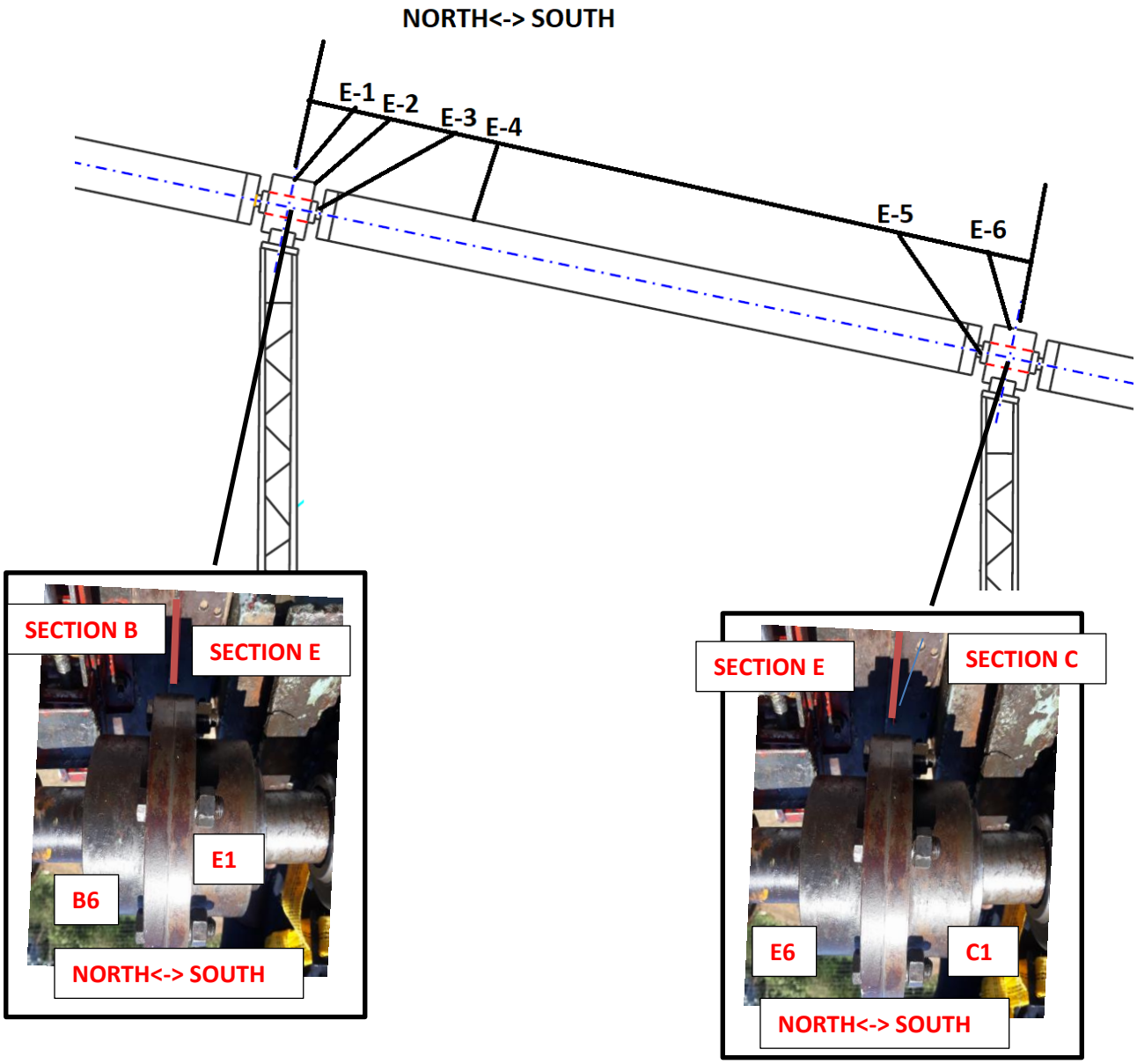
Interconnection System between S11&S12 , N11&N12:





Note: Here section A,B,C,D are same as previously mentioned interconnection section types.

SECTION E



E-1) Gear Coupling

E-2) Shaft for Gear coupling South side

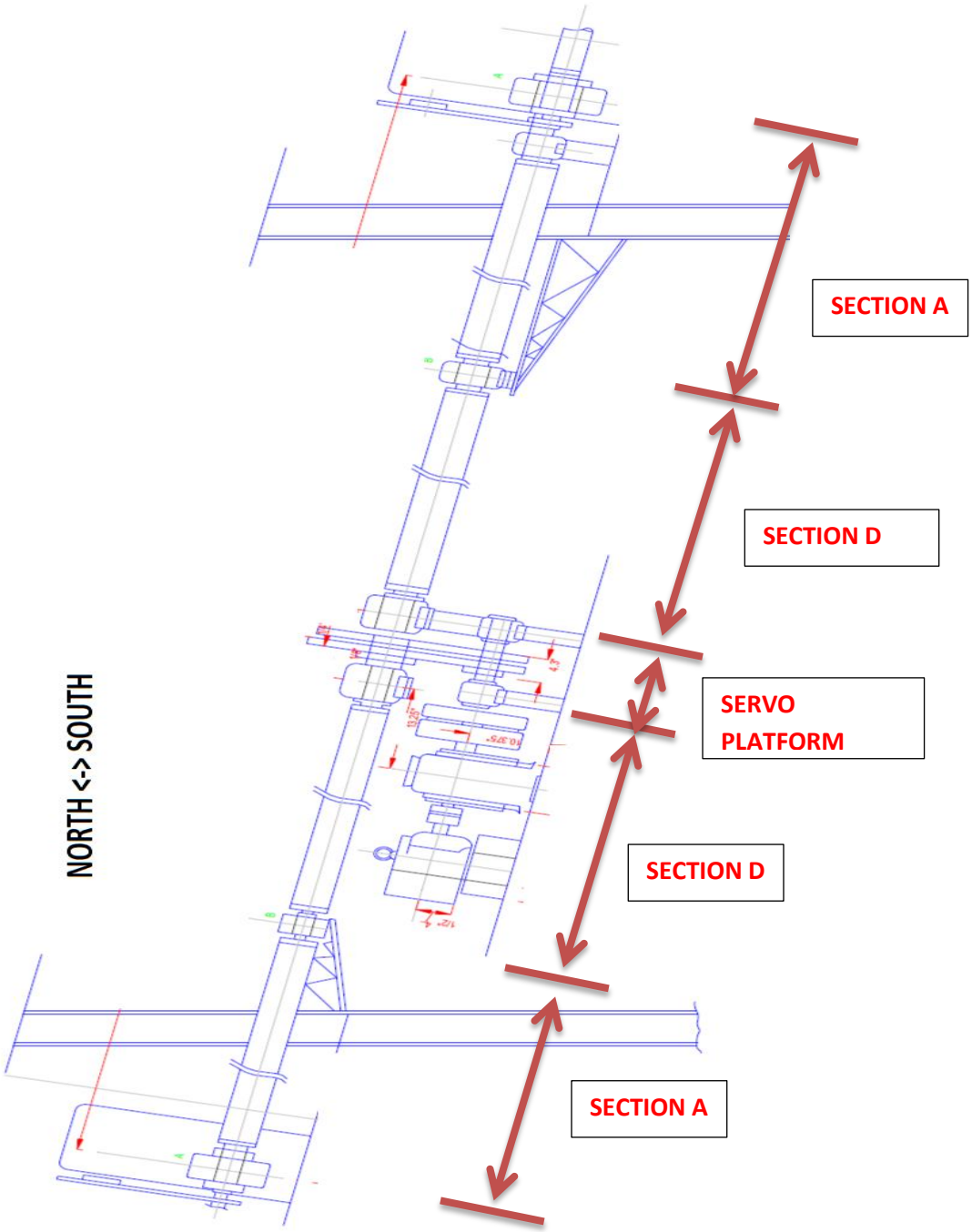
E-3) Self Aligning Ball Bearing

E-4) Drive Pipe shaft

E-5) Shaft For Gear coupling north side

E-6) Gear Coupling

Interconnection System between N1 & S1:

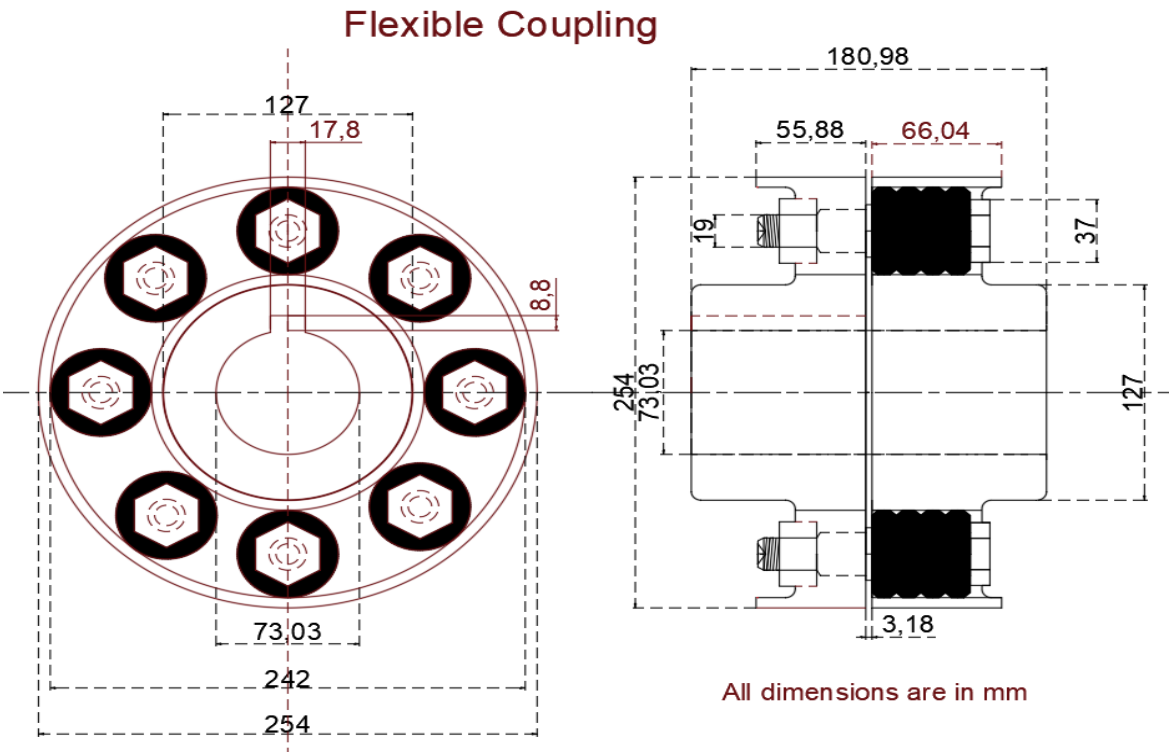


Note: Here section A,B,C,D are same as previously mentioned interconnection section types.

III . COMPONENT DETAILS

1) **Flexible Coupling:**

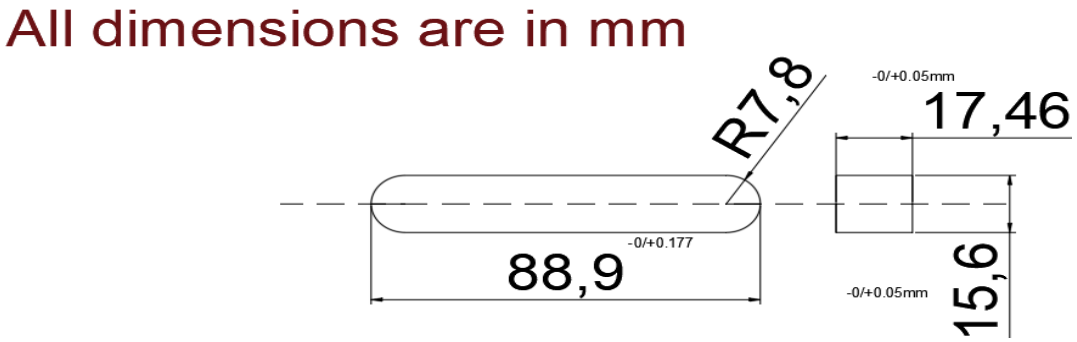
Vendor	**: David Brown**
Name	**: Bush type flexible coupling**
Type of Duty	**: Heavy**
No of Bolts	**: 8**
No of rings per Bolt	**: 4**
Hub material	**: Cast Iron**
Bolt Material	**: EN9 (HRC 30 to 32)**
Rings Material	**: Neoprene**
Bolt dimension	**: 1" dia x 115mm length**
Key material	**: MILD STEEL - IN ANNEALED CONDITION (NO HARDENING TO BE DONE)**



Key:

Material **: Mild steel**

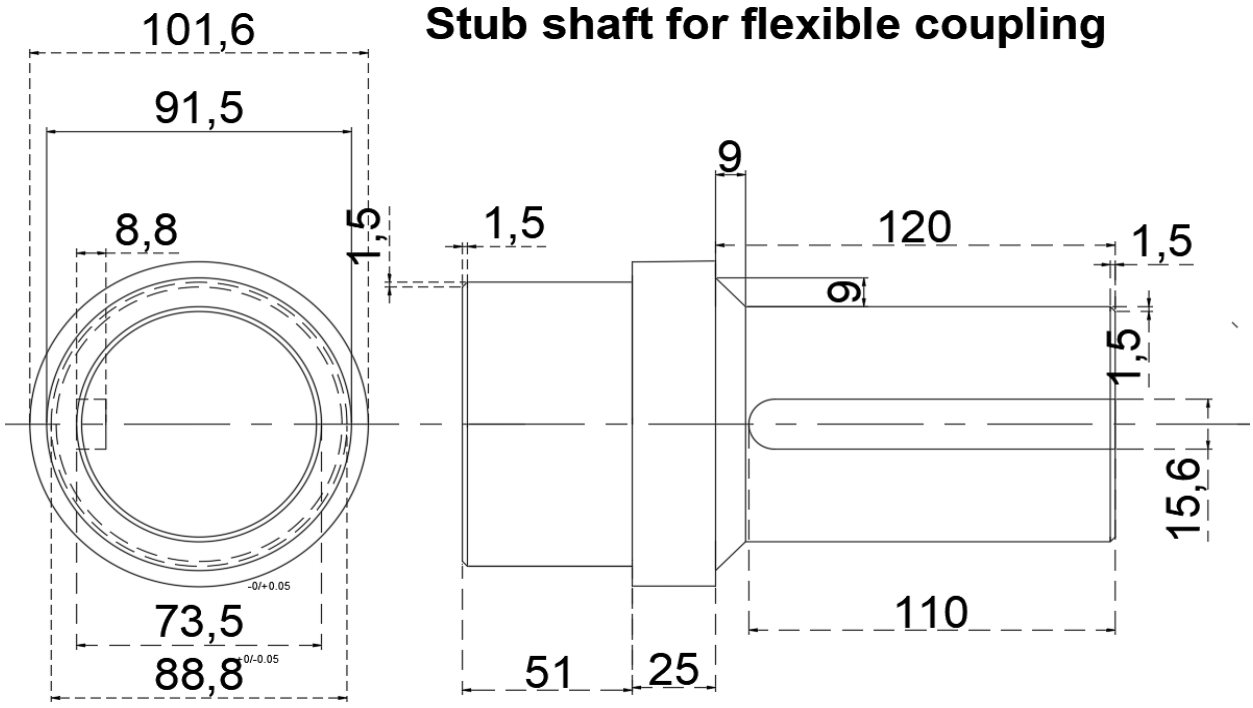
UTS **: 413.68 MPa**



2) Stub shaft for flexible coupling:

Material **: EN9**

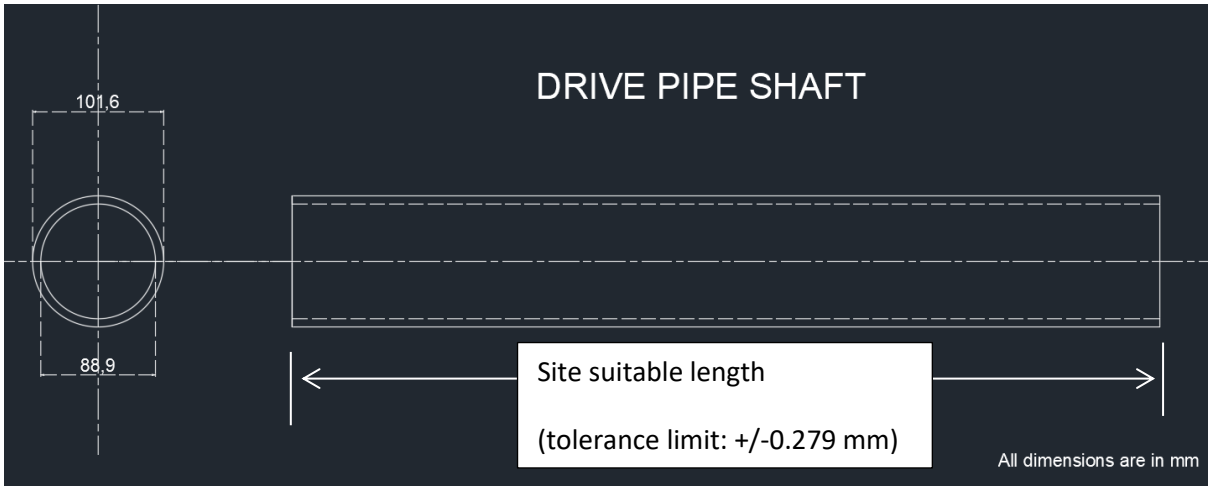
Min UTS **: 697.6MPA**



All dimension are in mm

3) Drive pipe shaft:

Material	**: AISI 4140**
UTS	**: 112000 PSI**
SIZE	**: 4 Inch**
THICKNESS	**: 0.25 Inch**

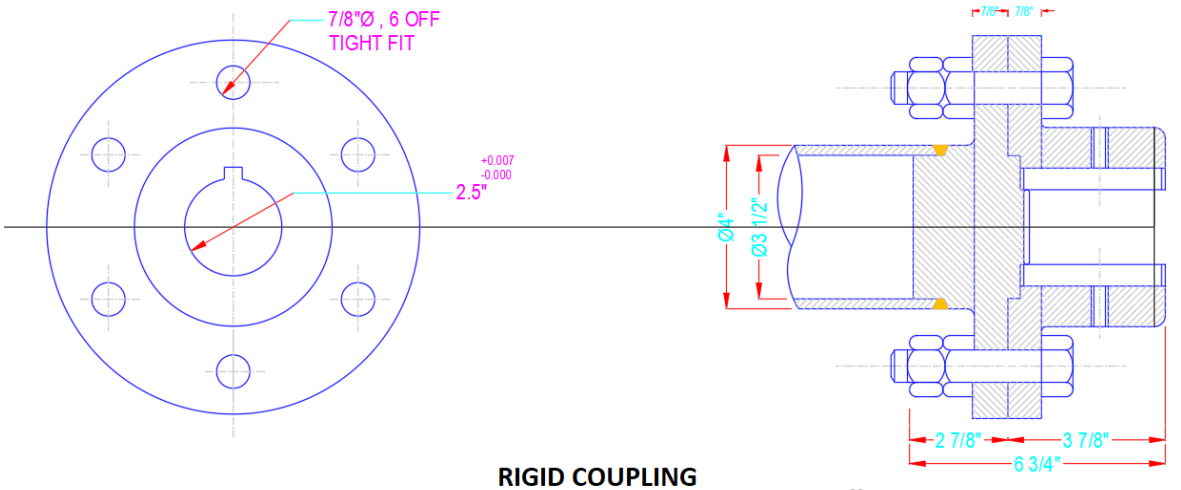


Note: As per standard, pipe supply length will be 6 meter. As per site requirement, length can be reduced.

4) RIGID COUPLING:

Coupling Hub Material	**: MILD STEEL**
Bolt material	**: MILD STEEL**
Bore Diameter	**: 63.5 mm (+0.1778/-0.000)**
Bolt size	**: 7/8" DIA X 4" length – 6nos**

Here, one side of the hub is connected directly with drive pipe shaft by welding, another side of hub is connected with drive pipe shaft through stub shaft and stub shaft is welded with drive shaft



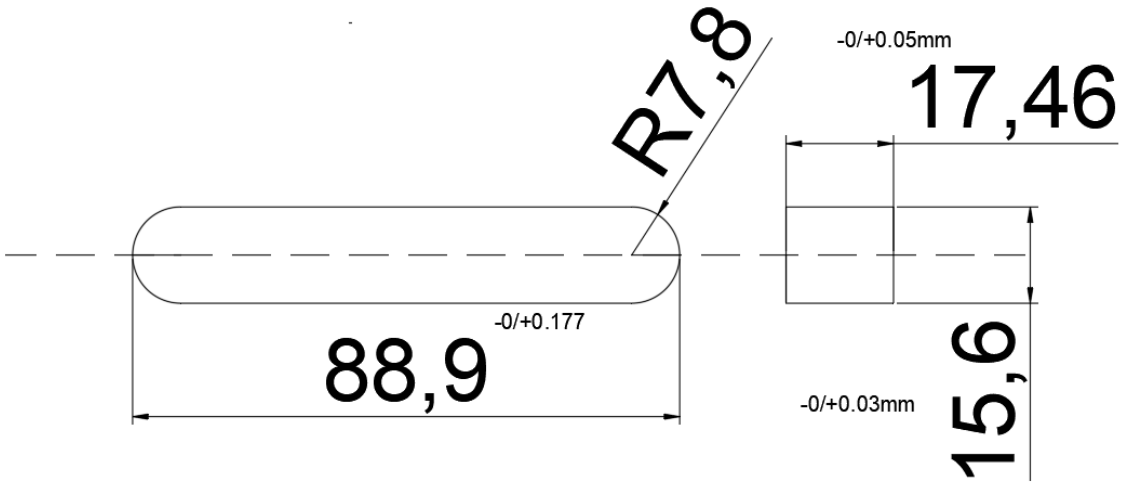
RIGID COUPLING

All Dimensions are in INCH

Key:

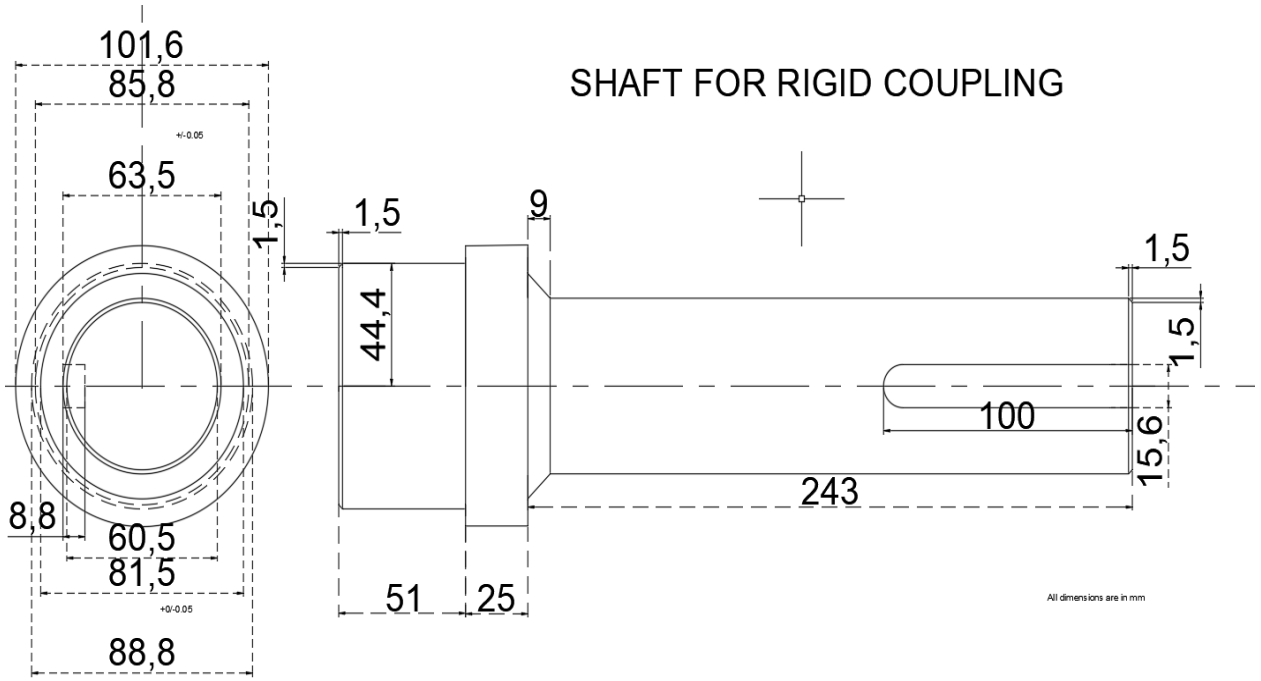
Material **: Mild steel**

UTS **: 413.68 MPa**



5) <u>Stub shaft for Rigid Coupling:</u>

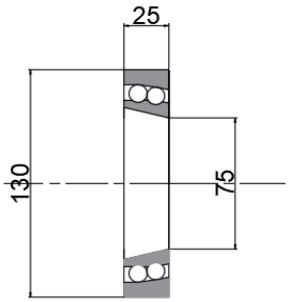
Material	**: EN9**
Min UTS	**: 697.6MPA**



6) <u>Self Aligning ball bearing with taper bore:</u>

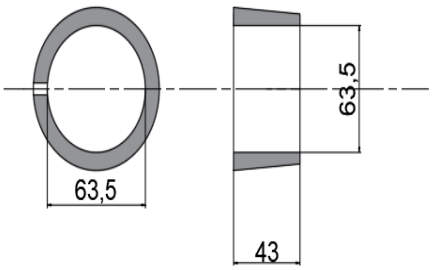
Type	**: 1215K**
No of Row	**: 2nos**
Clearance Group	**: Standard**
Bore	**: 75mm**
OD	**: 130mm**
Width	**: 25mm**

A) BEARING - SKF1215K:



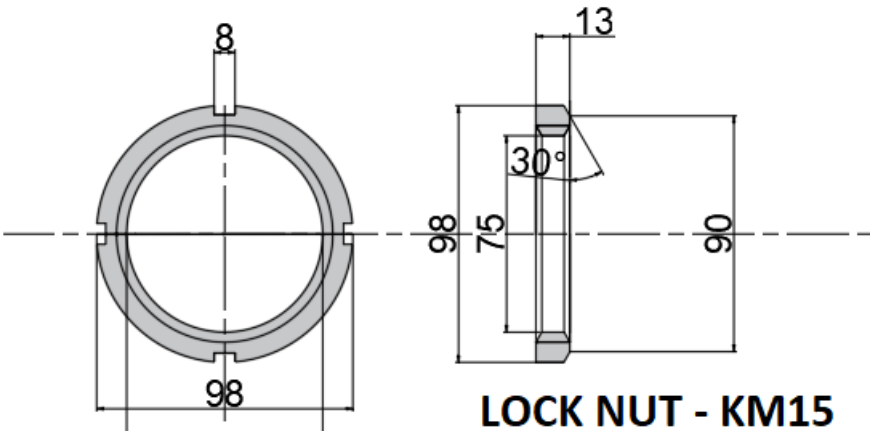
Self aligning Ball bearing with taper bore - SKF1215K

B) SLEEVE – H215:



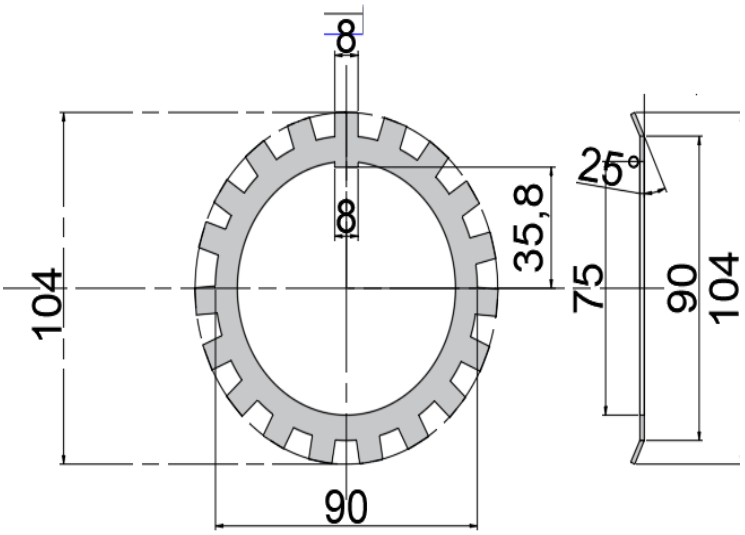
SLEEVE - H215

C) LOCK NUT – KM15 :



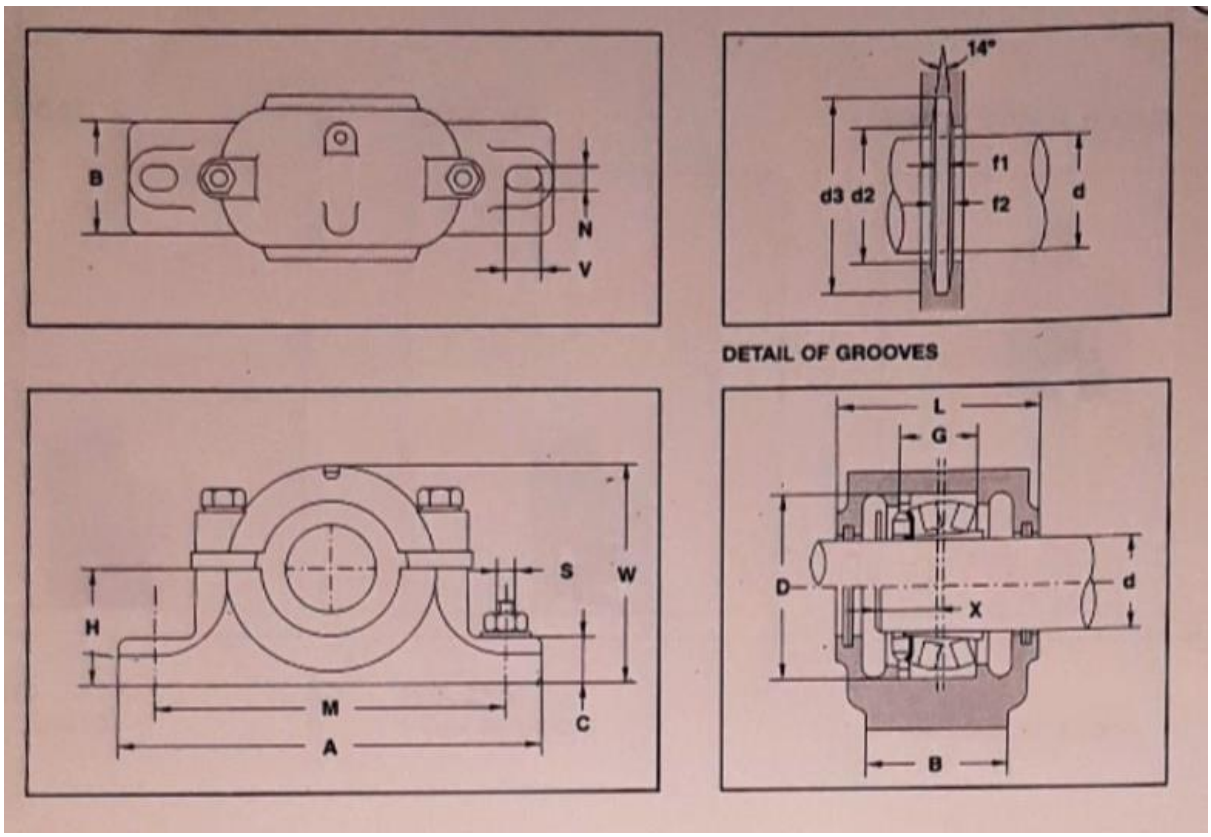
LOCK NUT - KM15

D) LOCK WASHER – MB15:



LOCK WASHER - MB15

E) Bearing Block (SN500 SERIES – SN515):

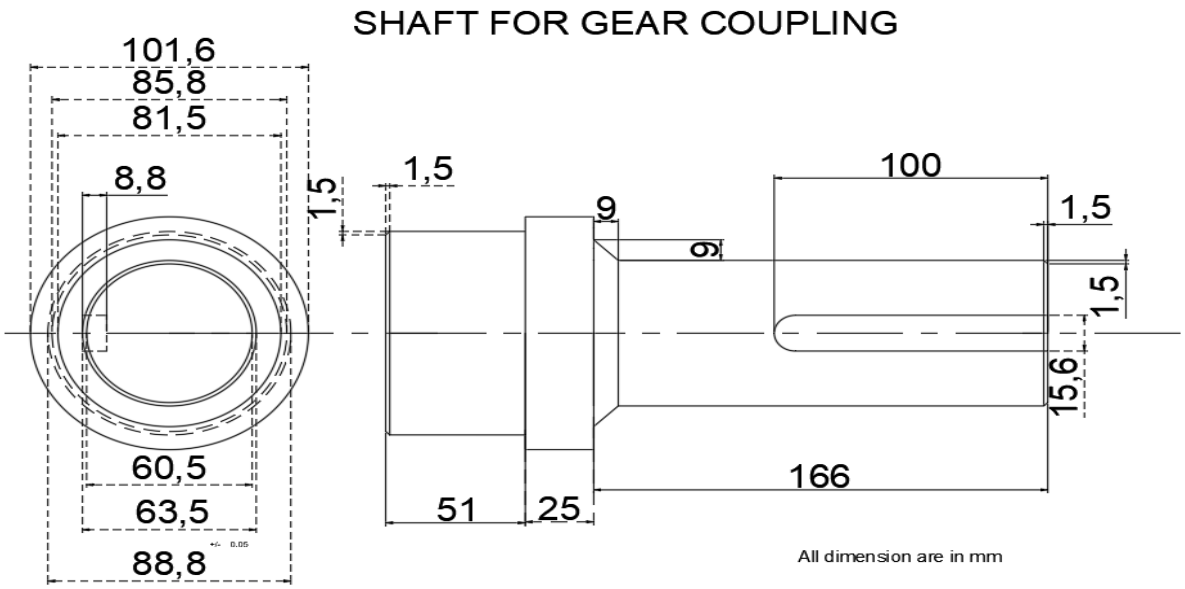


SERIES	d		DIMENSIONS mm																	
	MM	INCH	A	B	C	D	G	H	L	M	N	S	V	W	X	d2	d3	f1	f2	MASS kg
SN 515	65	2½	280	80	30	130	41	80	115	230	18	16	23	155	38	67.0	82	5	6.8	6.19

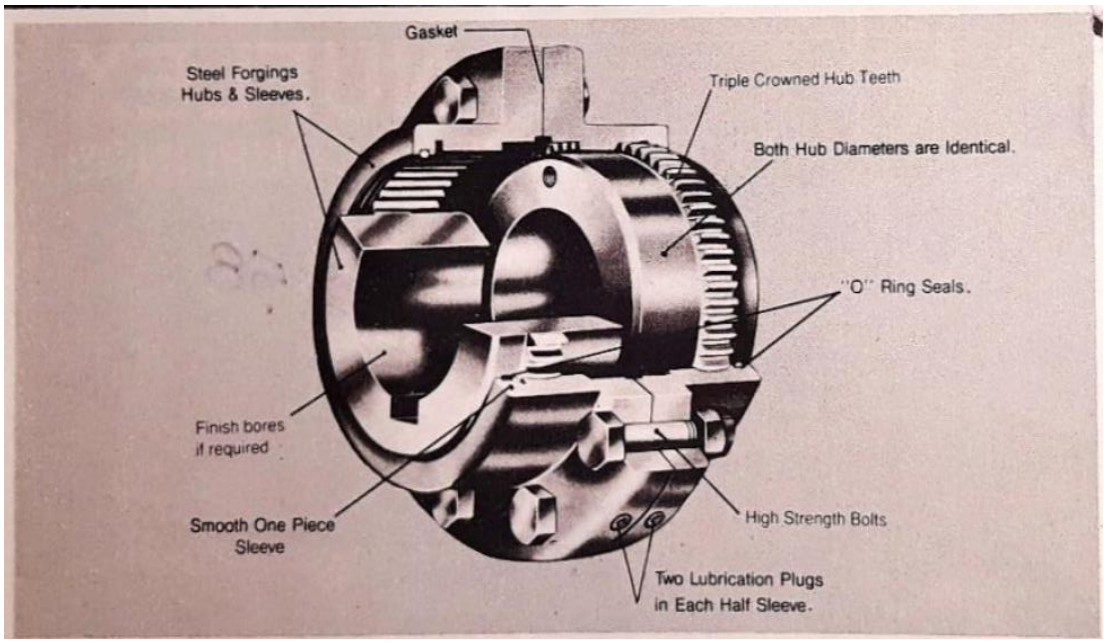
7) Stub shaft for Gear coupling North side:

Material : EN9

Min UTS : 697.6MPA



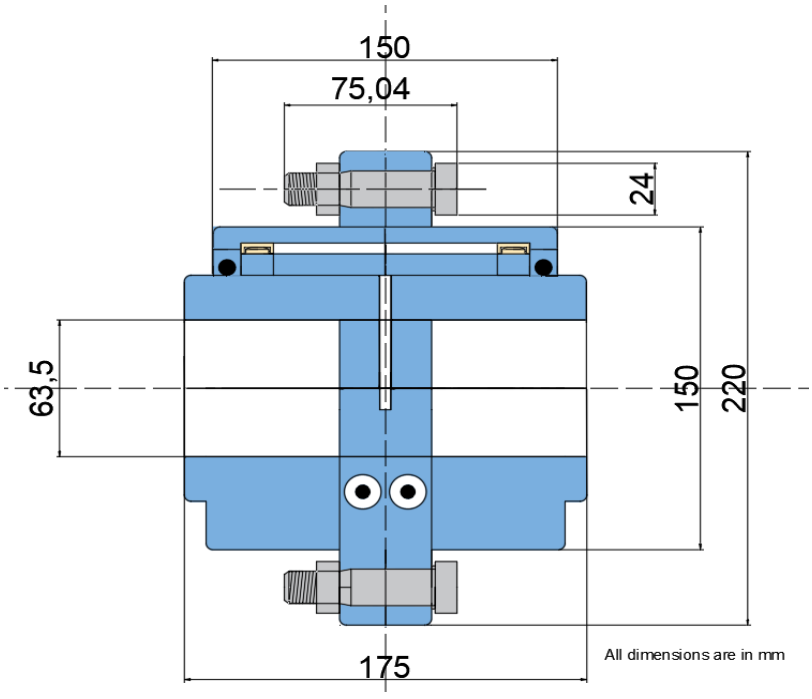
8) <u>NU –TECK Gear coupling:</u>



Company name **: Nu Teck**

Model **: GC 103**

Bore Diameter **: 63.5 (+/-0.2mm)**

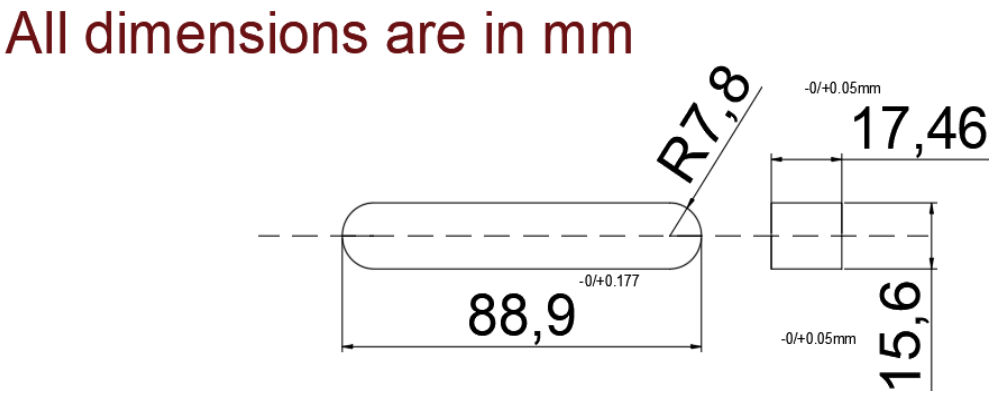


Note: Advantage of using Triple crown teeth hub is, max allowable misalignment will be 7.5 deg where as, it will be 1.5 deg in straight gear teeth.

Key :

Material : Mild steel

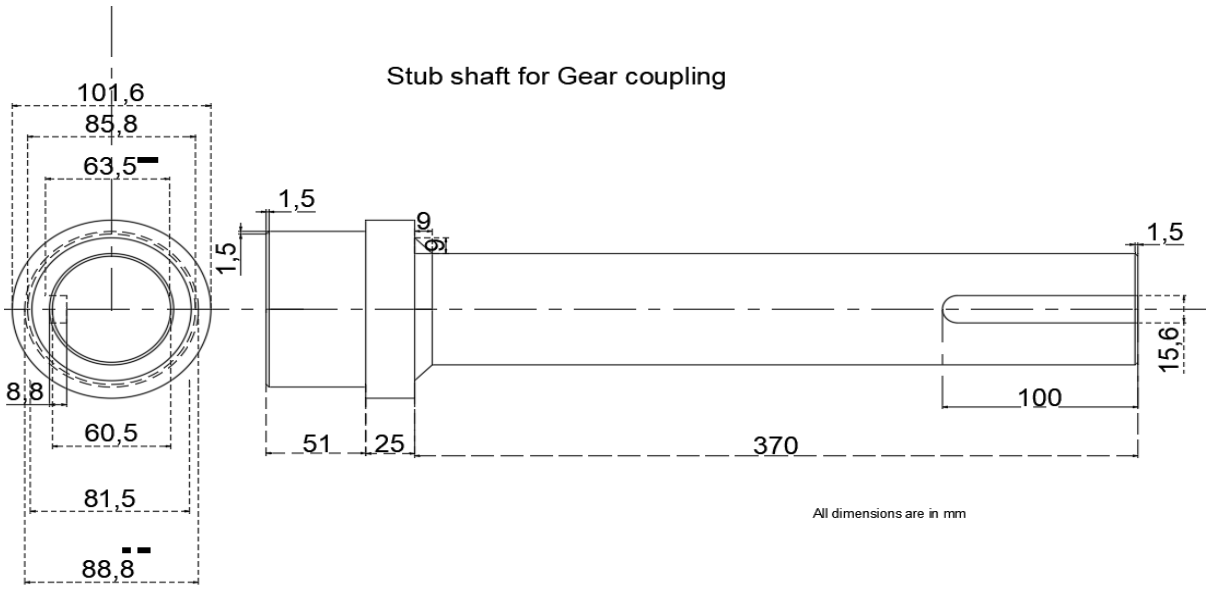
UTS : 413.68 MPa



9) Stub shaft Gear coupling south side:

Material : EN9

Min UTS : 697.6MPA



Note:

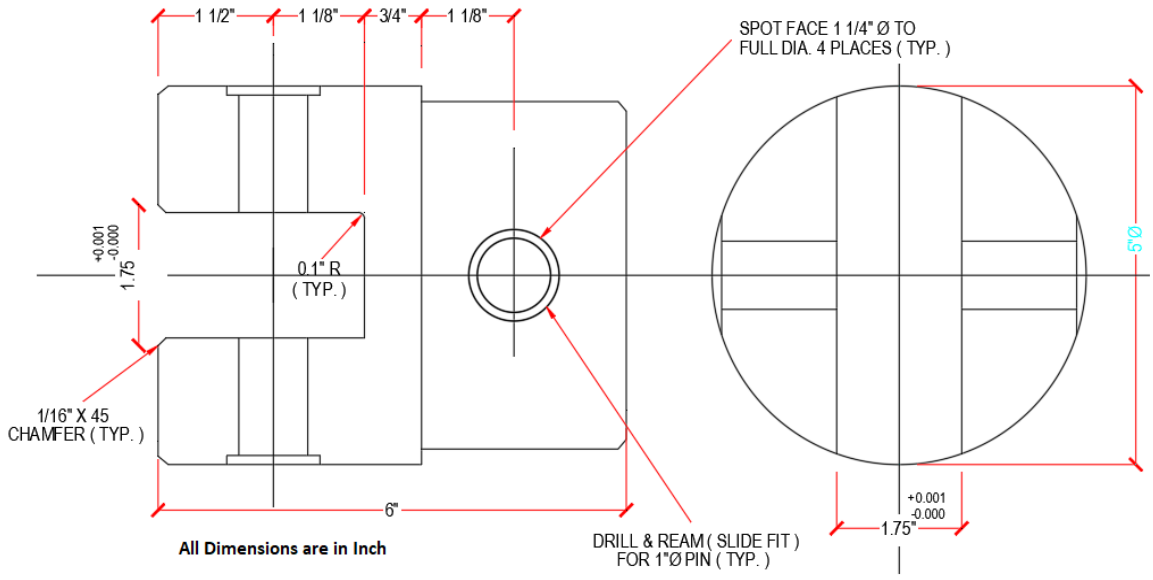
All platforms are interconnected with other platforms by using 10" flexible coupling on both sides except drive platform (N4, N10, S4, and S10)

Drive platform (N4, N10, S4, S10) are interconnected with other platform by using D- BODY SHAPE Coupling instead of Flexible Coupling.

10) D BODY COUPLING:

Material : EN9

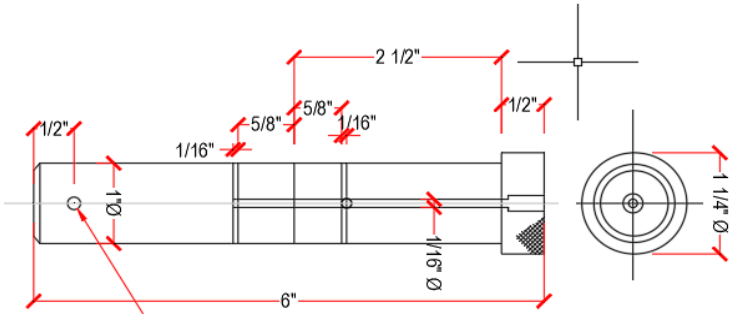
UTS : 880 MPA



Bolt:

Material **: EN9**

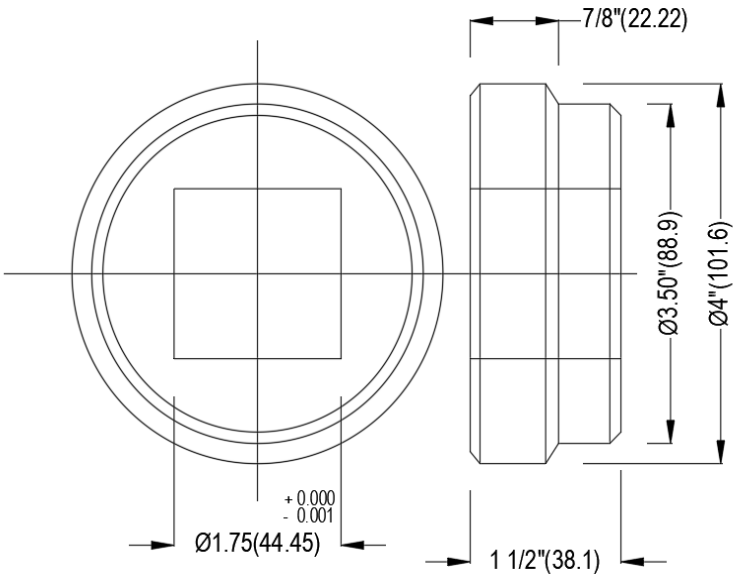
UTS **: 880MPa**



Bush for Sliding shaft:

Material **: EN9**

UTS **: 880 MPA**

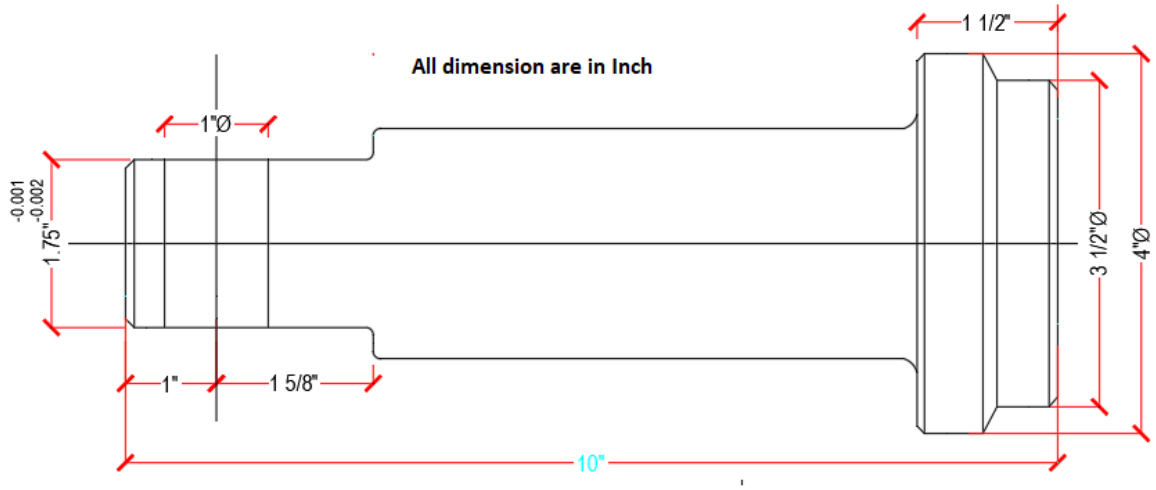


11) Shaft for D body shape coupling in North Side (Bearing shaft):

Material : EN9

UTS : 880MPa

BHN : 230 to 250

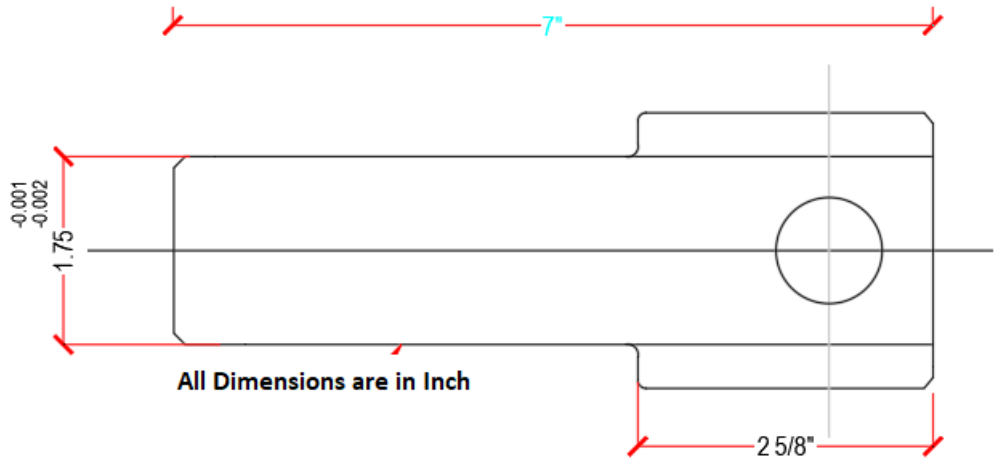


12) Shaft for D body shape Coupling South side (Sliding Shaft):

Material : EN9

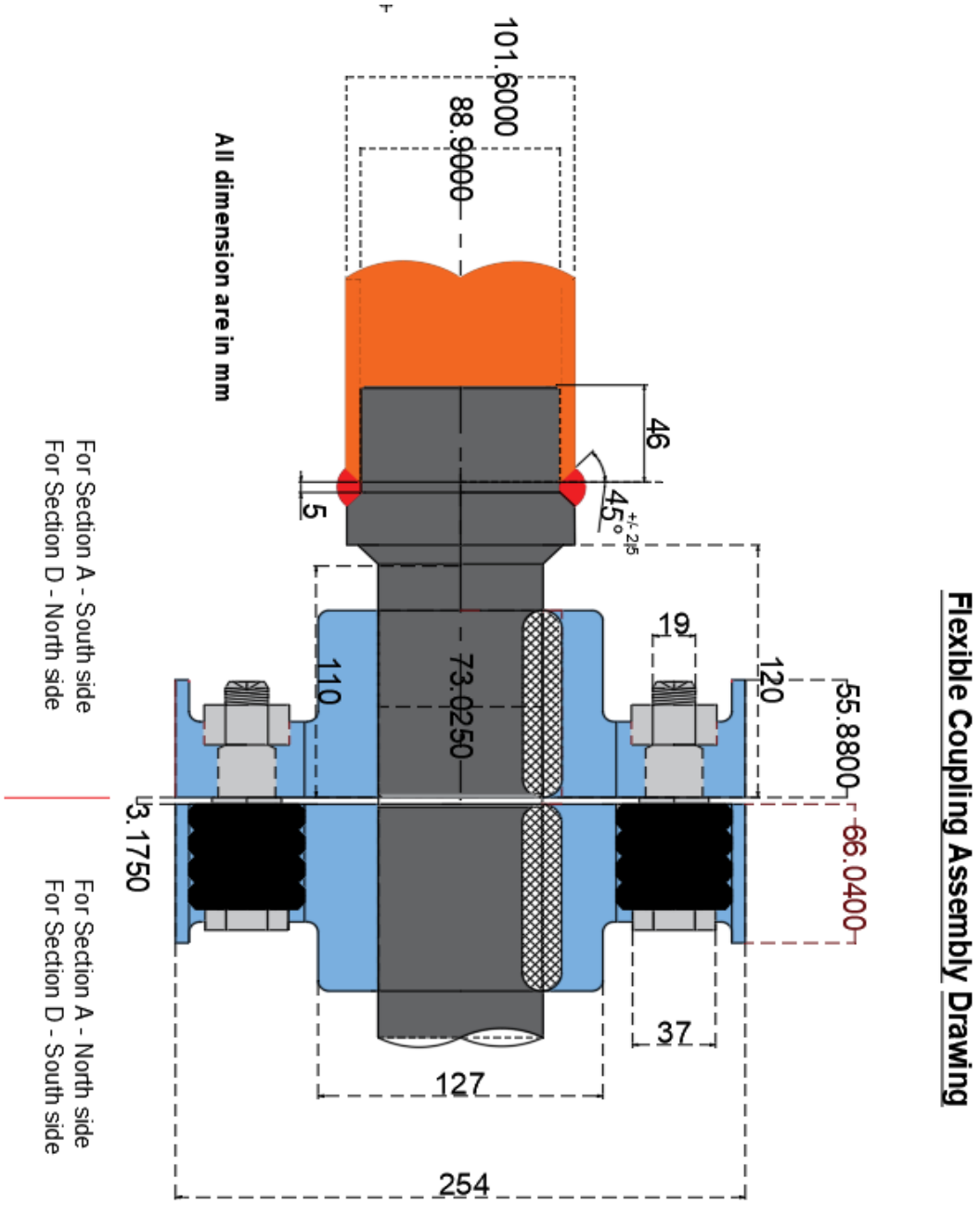
UTS : 880MPa

BHN : 230 to 250

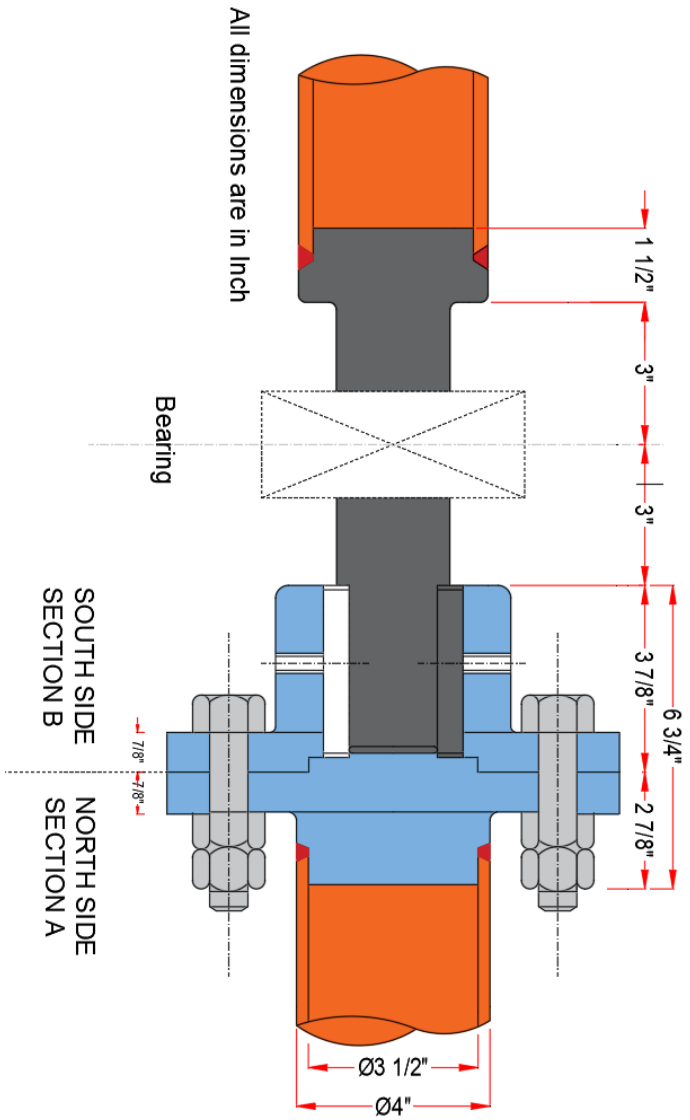


IV ASSEMBLY DETAILS

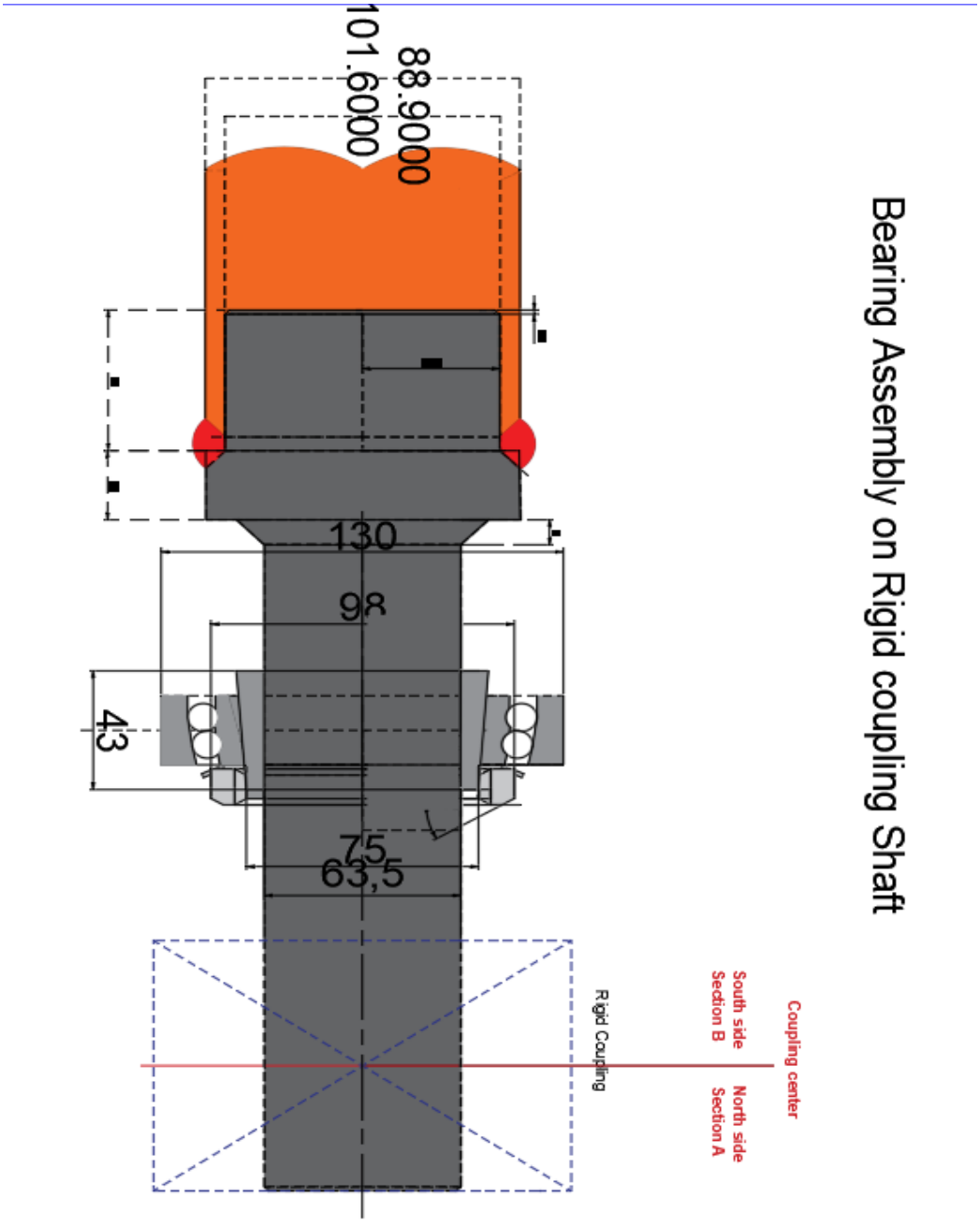
Flexible Coupling Assembly



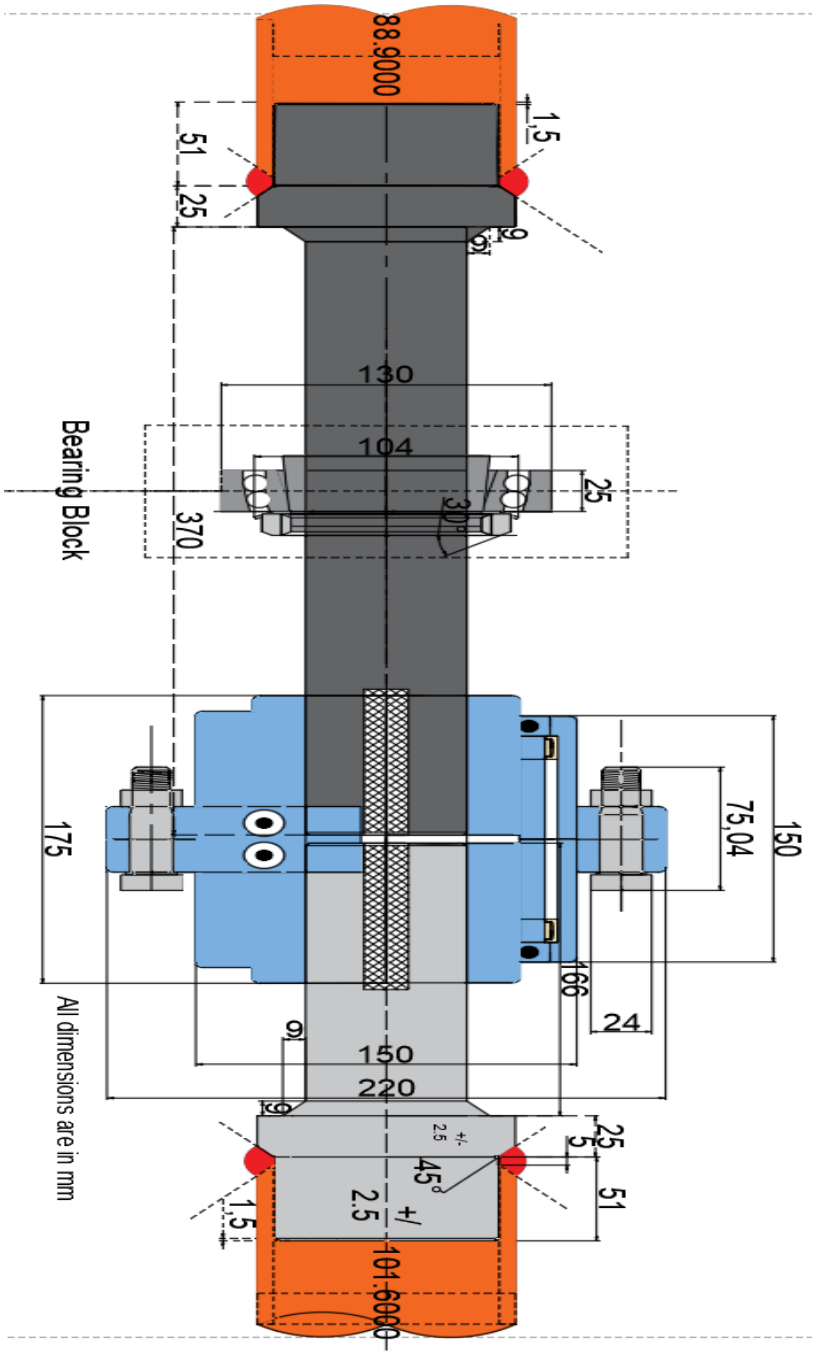
Rigid Coupling Assembly



Bearing Assembly



GEAR COUPLING ASSEMBLY



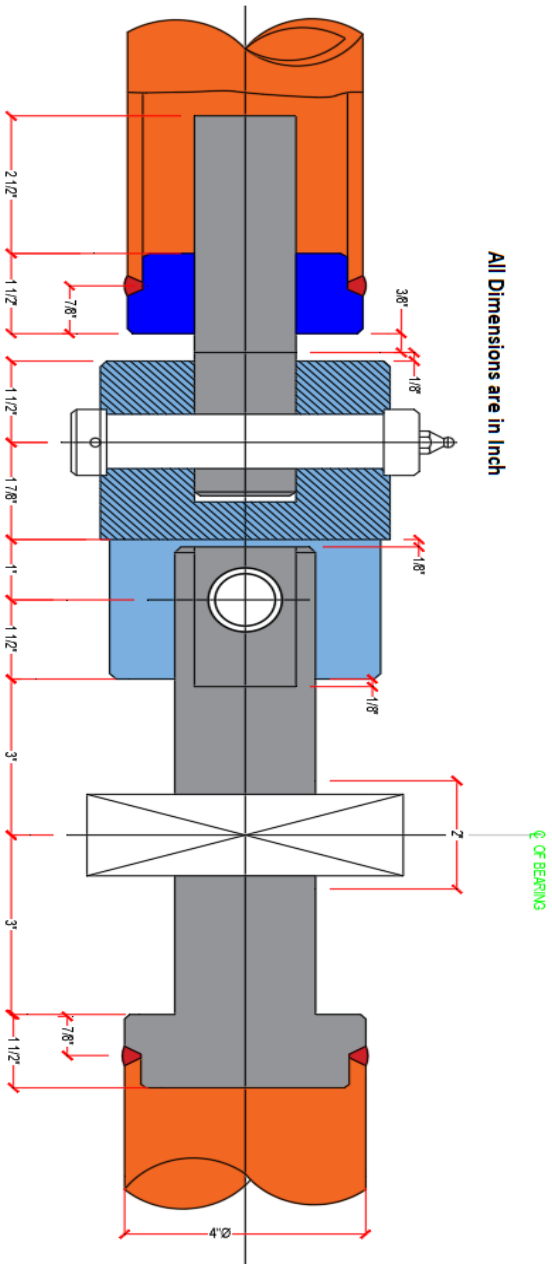
SOUTH SIDE

SECTION C

NORTH SIDE

SECTION B

D BODY SHAPE COUPLING ASSEMBLY



V. CONNECTIONS DETAILS:

SR NO	DETAILS1	DETAILS2	CONNECTION DETAILS
1	Flexible coupling Bore dia= 73.03 mm	Stub shaft OD = 73.5 (-0.000/+0.05mm)	Interference fit – with keyway shaft can be fixed with coupling bore as a Press fit by using Hydraulic press machine.
2	Stub shaft OD = 88.8 (-0.000/+0.05mm) Material : EN9	Drive pipe shaft ID = 88.9(+/- 0.279 mm) Material : AISI 4140	Clearance fit – drive pipe shaft and stub shaft is fixed by SMAW welding. Electrode- EUTECTRODE 680
3	Drive pipe shaft OD/ID = 101.6/88.9(+/- 0.279 mm) Material : AISI 4140	Rigid coupling hub ID/OD = 101.6/88.9 (+/- 0.279 mm) Material : Mild steel	Drive pipe shaft and rigid coupling hub can be joined by using SMAW welding. Electrode- EUTECTRODE 680
4	Rigid coupling hub Bore = 63.5mm(+/- 0.279 mm)	Rigid coupling Stub shaft OD = 63.5mm(+/-0.05mm)	Transition fit - with keyway shaft can be fixed with coupling bore as a Push fit by using Hydraulic press machine.
5	Rigid coupling Stub shaft OD = 63.5mm(+/- 0.05mm)	SKF1215K bearing sleeve bore Dia = 63.5mm (-0.015/+0.000)	Transition fit - shaft can be fixed with bearing as a Push fit.
6	Stub shaft for Gear coupling North side OD= 63.5mm(+/-0.05) Material : EN9	Gear coupling Sleeve Bore Diameter = 63.5(+/- 0.2mm)	Transition fit – with keyway shaft can be fixed with Gear coupling bore as a Push fit by using Hydraulic press machine.
7	Gear coupling Sleeve Bore Diameter = 63.5(+/- 0.2mm)	Stub shaft for Gear coupling OD= 63.5mm(+/- 0.05) Material : EN9	Transition fit – with keyway shaft can be fixed with Gear coupling bore as a Push fit by using Hydraulic press machine.
8	D Body Hub slot size =44.45mm(+0.0254/- 0.00)	Bearing shaft hub side width = 44.45mm (-0.0508/-0.0254)	Clearance Fit – Sliding shaft can be fixed in the hub as a sliding fit.
9	Drive pipe shaft ID = 88.9(+/- 0.279 mm) Material : AISI 4140	Sliding shaft Bush OD= 88.9 (-0.00/+0.05mm)	Transition fit - shaft can be fixed with hub as a Push fit and followed by SMAW by using electrode 680.
10	D BODY SHAPE HUB Sliding shaft Bush square slot= 44.45 (-0.00/+0.0254mm)	Sliding shaft Square end = 44.45 (-0.0508/-0.0254)	Clearance Fit – Sliding shaft can be fixed in the hub as a sliding fit.

Note:

1) Flexible coupling hubs are connecting with each other's by using 8nos EN9 bolt with 32nos Neoprene rubber bush fit.
2) Rigid coupling hubs are connecting with each other's by using 6nos – 7/8 " EN9 bolt
3) Gear coupling hubs are connecting with each other's by using 6nos – 5/8 " EN8 bolt

VI. COMPARSION

Inside the Platforms,

In all 24nos platforms and 1nos Servo platform, only solid EN9 shafts are used for power transmission. There is no AISI 4140 drive pipe shafts are used inside the platform.

- All platforms are permanently fixed with ground level, so there is no vibration except vibration induced by moving parts

- Length of shaft (less than a meter) which are used inside the platform for power transmission are considerably very small with compare to drive pipe shaft which have used in between platform for interconnection and power transmission . So chances of the deflections due to self-weight are very less. (Note: inherent out of roundness will be checked and same will be confirmed within allowable limit)

- Moe than one self-aligning ball bearings are used in a shorter length , which ensure the concentric rotation of the shaft throughout its life

Due to above reasons chances of EN9 shaft failures inside platforms are not usual except due to material defect and dimensions problem.

Between the Platforms,

All 24nos and servo platforms are interconnected by using various mechanical components as described already in details,

1. **Coupling:**
    - Flexible coupling
    - Rigid Coupling
    - Gear Coupling
    - D body shape coupling

2. **Shafts:**
    - Stub shaft for flexible coupling
    - Stub shaft for Gear coupling north side
    - Stub shaft for Gear coupling south side
    - Stub shaft for rigid coupling

3. **Self-Aligning ball bearing with taper sleeve**

4. **Drive pipe shaft**

Mainly for power transmission from one platform to another platform, Drive pipe shaft are used which having the distance of 23 meters approximately,.

The additional problems which can arise from drive pipe shaft with compare to solid EN9 shaft:

- Total length of the drive pipe shafts are not supported continuously with ground.

- Length of shaft are really high (3 to 4 meters) with compare to Solid EN9 shaft which are used inside platforms. So chances of deflection due to self-weight are high in operation. (Note: drive pipe shaft supply length will be 6 meter or 12 meter, but not less than that. During the shipment if it is not properly supported at required length intervals, then it can bend easily. The created deflection will lead to more problems in drive pipe shaft during operation and leads to its failure.

- Minimum 3nos to max 4nos of self-aligning ball bearing are used in between 23 meters length of the shaft. Due to high shaft length, if unavoidable misalignment due to assemblies are generated, when its crosses the bearing load limit and flexible coupling misalignment range , its lead drive pipe shaft failure.

So chance of failures are higher in-between the platform than the inside platform

Note: As described above, the successful ORT operations are also witnessed more problems in drive pipe shaft assembly only.

Type of problems can arise from drive pipe shaft interconnection are,

- Drive pipe shaft cut due to its own weight deflection.
- Stub shaft cut due to material defect
- Stub shaft cut at sharp corner due to No neck radius or inadequate Neck radius.
- Bearing failure

So, it is better to replace the complete drive pipe shaft, stub shaft with bearing assembly irrespective of which portion got cut, to avoid invisible damages from uncut portion affects the new replaced part.

Note: Required inventory for drive pipe shaft, stub shaft and bearings are maintained in RAC

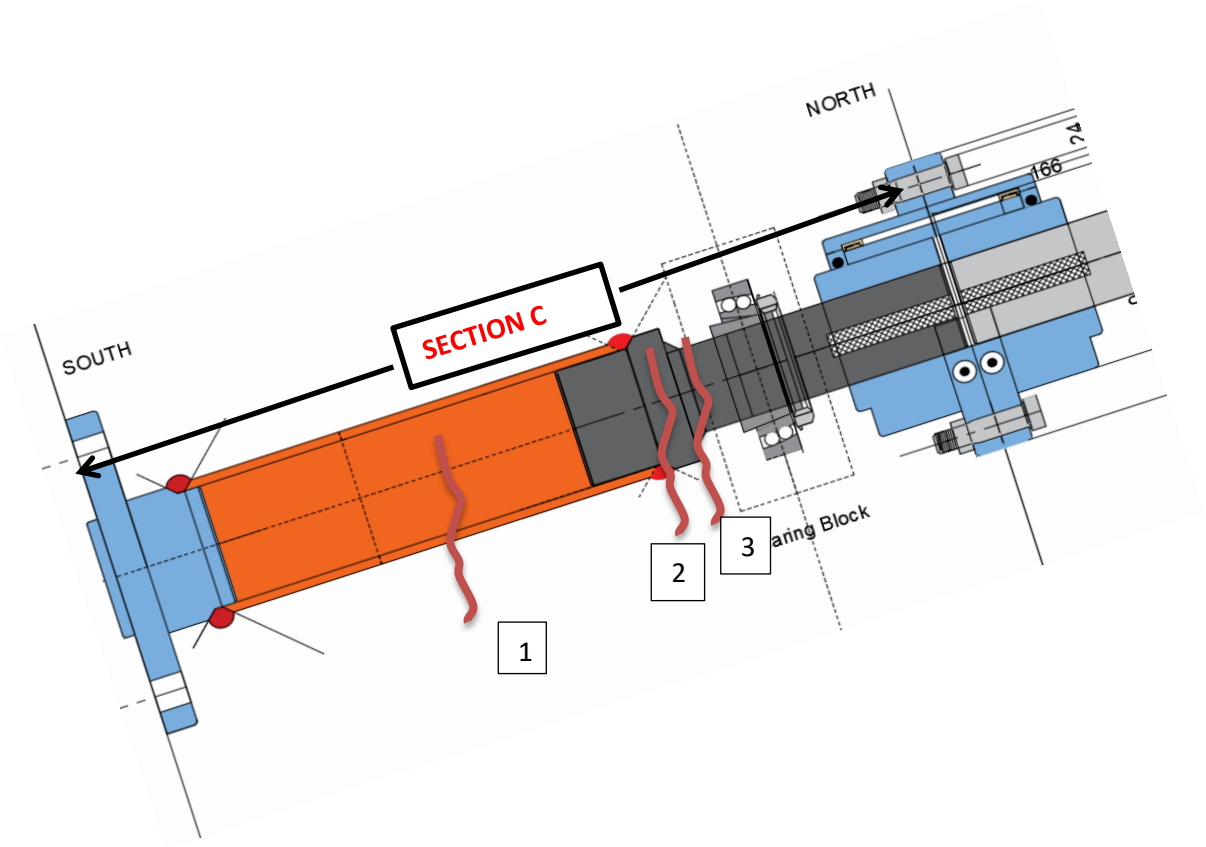
Coupling can be re-used till the bore gets damaged. The weakest part in the coupling is key. Key will get break first due to any misalignment, so that coupling hub will not get any damage. Also coupling single hub cannot be replaced alone because of the different tolerance limits. Only complete assembly can be replaced. There are no enough inventories maintained in RAC.

So it is better to reuse the coupling instead of replacement when it is in re-usable condition.

As discussed in previous, all sections are almost same .The type of coupling and stub shaft which are used for coupling to drive pipe shaft interconnection are only different. So, the procedure for cut portion replacement is same for all sections.

VII. Procedure to be followed for drive pipe shaft assembly replacement:

Let's Consider, cuts are generated in section C.



Cut location possibility:

- Cut in the drive pipe shaft anywhere
- Cut in the stub shaft anywhere
- Cut in sharp edge due to no neck radius or inadequate neck radius

1) Discontinuity location side shall be identified by proper SOP based upon which system trips ORT (synchro, Encoder or mis-alignment loop)

2) Physical discontinuity location shall be identified by field visit in identified side by using proper system SOP.

3) After discontinuity identification, MCC shall be switch off and brake normally closed condition shall be ensured.

4) ORT hour angle position shall be note down.

5) If ORT position is in complete west limit or near to west limit then, stow lock shall be provided in both side immediate tower.

6) First visual observation details shall be filled in **Annexure A**

Note: Outcome of Annexure A,

1) Reason for discontinuity
2) How to avoid this problem in future

Outcome shall be included as modification in repairing job.

7) First South side Rigid coupling lock pin shall be removed from all 6nos bolts.

8) Rigid coupling bolts shall be removed one by one.

9) North side Gear coupling all bolts 6nos shall be removed one by one.

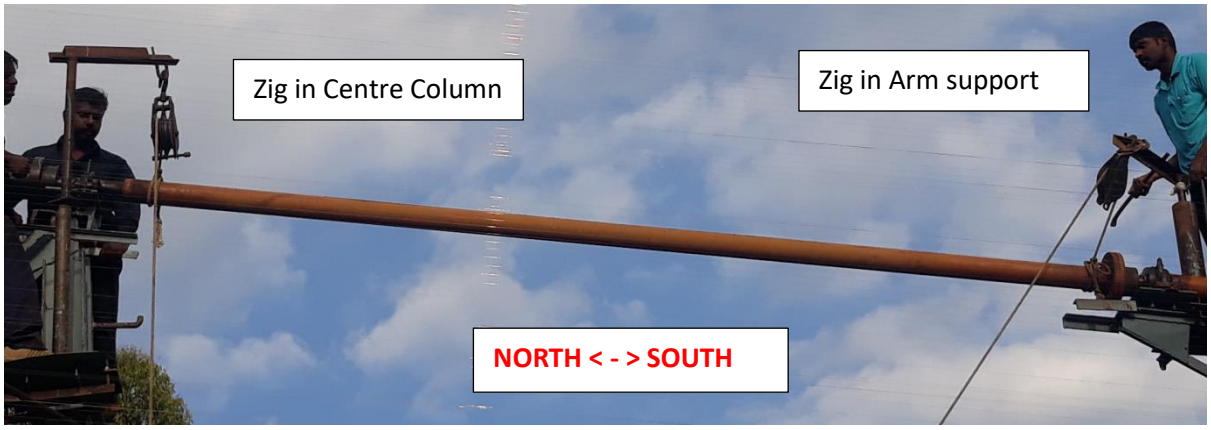
10) Both coupling shall be left out with 2nos bolt with nut at 180 deg apart in hand tight

11) North side plumber block top sleeve shall be opened after removing the 2nos nut with washer from the top sleeve.

12) All grease shall be removed from inside the plumber block.

13) Zig assembly shall be fixed with rope pulley one in arm support and another one in center column for shaft dismantling and shifting to the ground position.

(Note: Center column zig assembly shall be having more height than arm support)



14) After Zig Assembly and rope tie up on both ends, remaining bolts shall be removed from both end coupling and coupling hub shall be loosened.

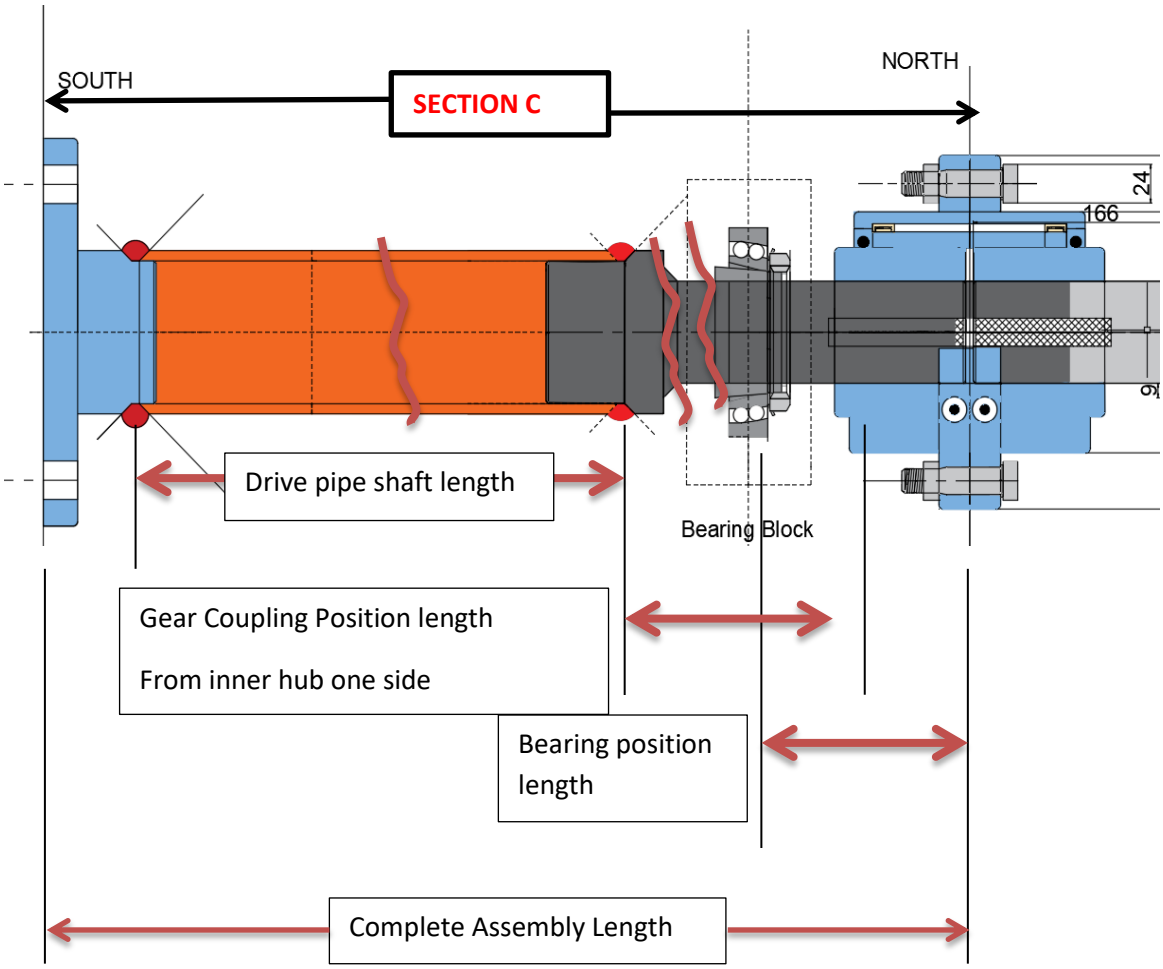
15) By using center column Zig assembly support drive pipe shaft assembly shall be lifted out of plumber block first.

16) After bearing removed out of plumber block , by using both Zig assembly , drive pipe shaft shall be dismantled completely and to be brought to the ground level

Note: If drive pipe shaft assembly are into two pieces due to cut, both shall be dismantled separately.

17) Removed drive pipe shaft shall be shifted to maintenance shed and to be kept on Ground fixed V block.

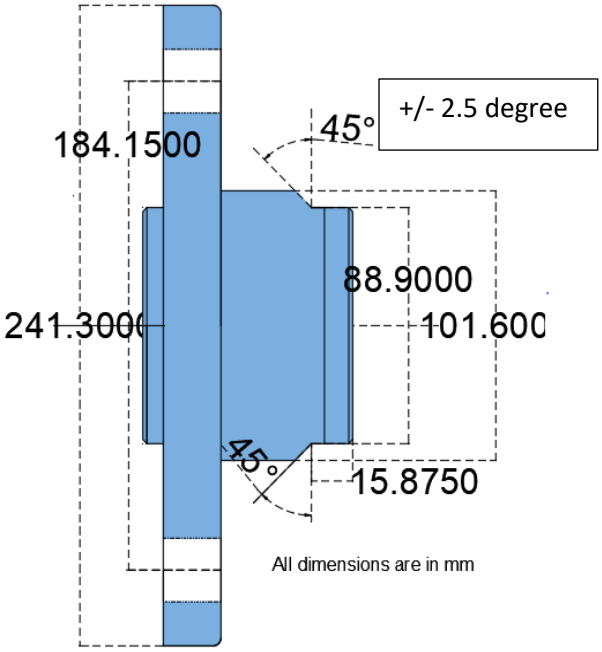
18) Cut Pieces of drive pipe shaft assembly shall be assembled as single piece by using SMAW welding and complete measurement shall be taken as given below.



19) As mentioned before, it is better to replace drive pipe shaft, stub shaft with bearing and coupling, plumber block can be reused if there is no visible damage in that.

Note: If any visible damage found in coupling, plumber block, same shall be replaced with new one.

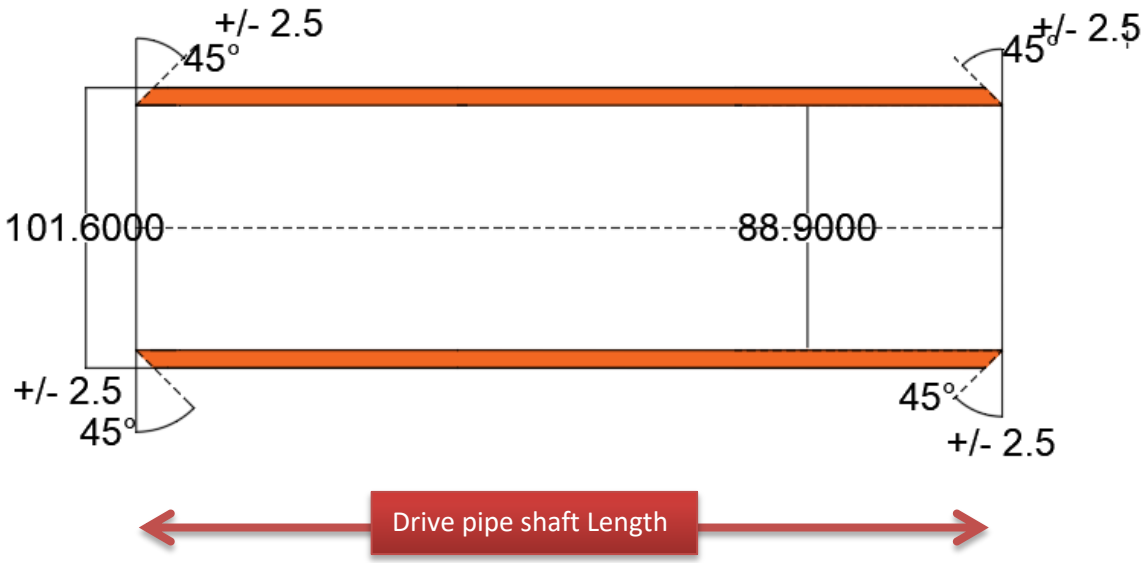
20) Rigid coupling shall be removed from drive pipe shaft by weld cutting with grinding machine and edge shall be prepared as show below,



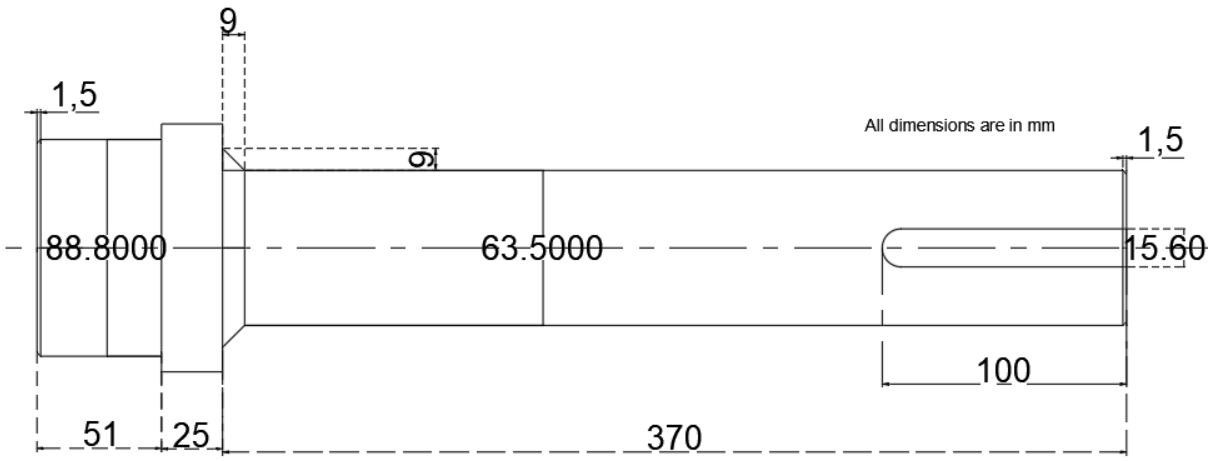
21) Gear coupling inner hub shall be removed from stub shaft by using bearing puller and followed by coupling sleeve removal from stub shaft. Removed coupling inner hub and sleeve shall be inspected thoroughly for visible damage and after proper cleaning.

22) New Drive pipe shaft shall be cut from supplied long pipe as per measured drive pipe shaft length and out of roundness shall be checked at min 4 location by using magnetic dial gauge on V block.
Note: Out of roundness should be within OD tolerance limit. (OD: 101.6mm +/0.279mm)

23) After out of roundness found within limit , drive pipe shaft edge preparation shall be done as given below,



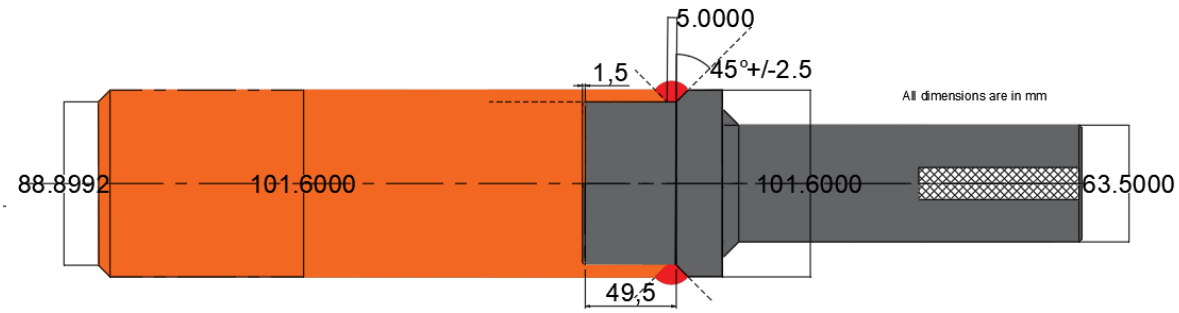
24) Stub shaft for gear coupling for south side shall be machined from the supplied shaft as per required dimension given below,

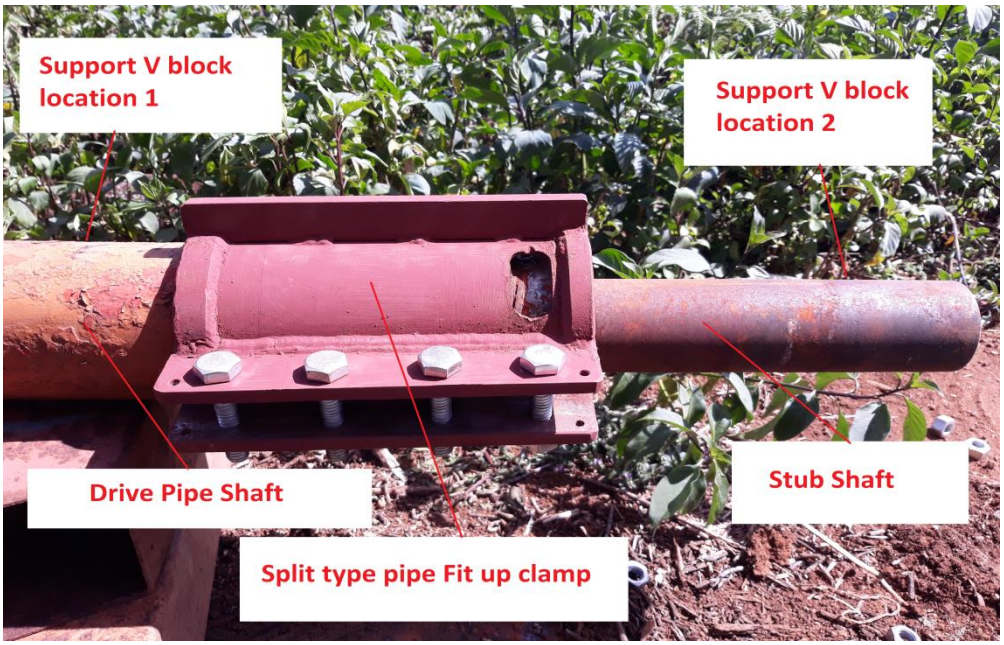


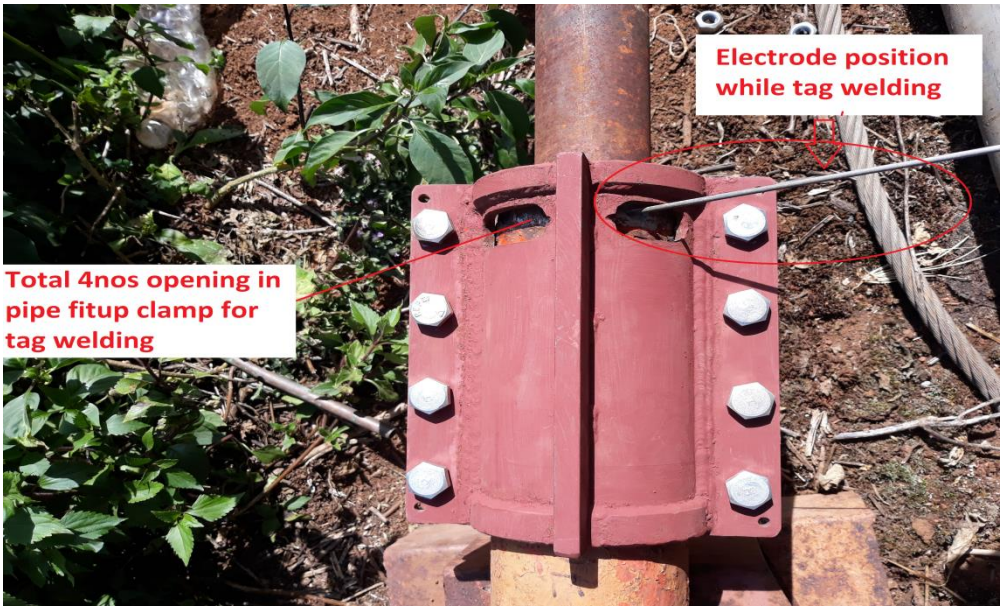
25) Out of Roundness shall be checked at both ends. it should be within the tolerance limit (**Note: Out of roundness should be within OD tolerance limit. (OD: 63.5mm +/0.05mm & 88.8 +/0.05mm)**

26) Drive pipe shaft and stub shaft for gear coupling south side alignment shall be done by using pipe fit up clamp and fit up shall be as per given details below,

Note: Fit up can be done by supporting drive pipe shaft and stub shaft on V block only and this fit is clearance fit.


5.0000
1.5
45°+/-2.5
All dimensions are in mm
88.8992
101.6000
101.6000
63.5000
49.5


Support V block location 1
Support V block location 2
Drive Pipe Shaft
Stub Shaft
Split type pipe Fit up clamp


Electrode position while tag welding
Total 4nos opening in pipe fitup clamp for tag welding

27) After Fit up, tag welding shall be done using SMAW with Electrode: Eutectrode 680.

28) After tag welding, Pipe Fit up clamp shall be removed and followed by welding as per Annexure B.
Note: Heat treatment procedure shall be followed as per Annexure B

29) After Heat treatment process , shaft surface shall be made free from debris by using grinding polish wheel

30) After proper surface cleaning Bearing shall be mounted on measured bearing location.

Bearing	**:**	**SKF1215K**
Sleeve	**:**	**H215**
Lock Nut	**:**	**KM15**
Lock washer	**:**	**MB15**

31) Sleeve shall be mounted on the shaft at previously measured bearing location followed by bearing insertion

32) Locknut and washer shall be place in the position and followed by lock nut hand tight only.
Note: Lock washer extension shall be bend in lock nut slot during final installation time only

33) Grease shall be applied immediately after installation of the bearing and followed by proper covering to avoid contamination.

34) After bearing installation, Gear coupling south side sleeve shall be inserted and followed by south side inner hub installation as per measured gear coupling position length as Push Fit with Key.

35) After Gear coupling south side inner hub installation, Complete Assembly shall be shifted to ORT original position to fit up Rigid coupling north side hub to drive pipe shaft assembly by using fit up clamp.

Note: by Rigid coupling north side hub fit up in ORT original position will mainly avoid two major problems:

a) Complete drive pipe shaft assembly length mismatch
b) Both coupling hub bolt holes mismatch

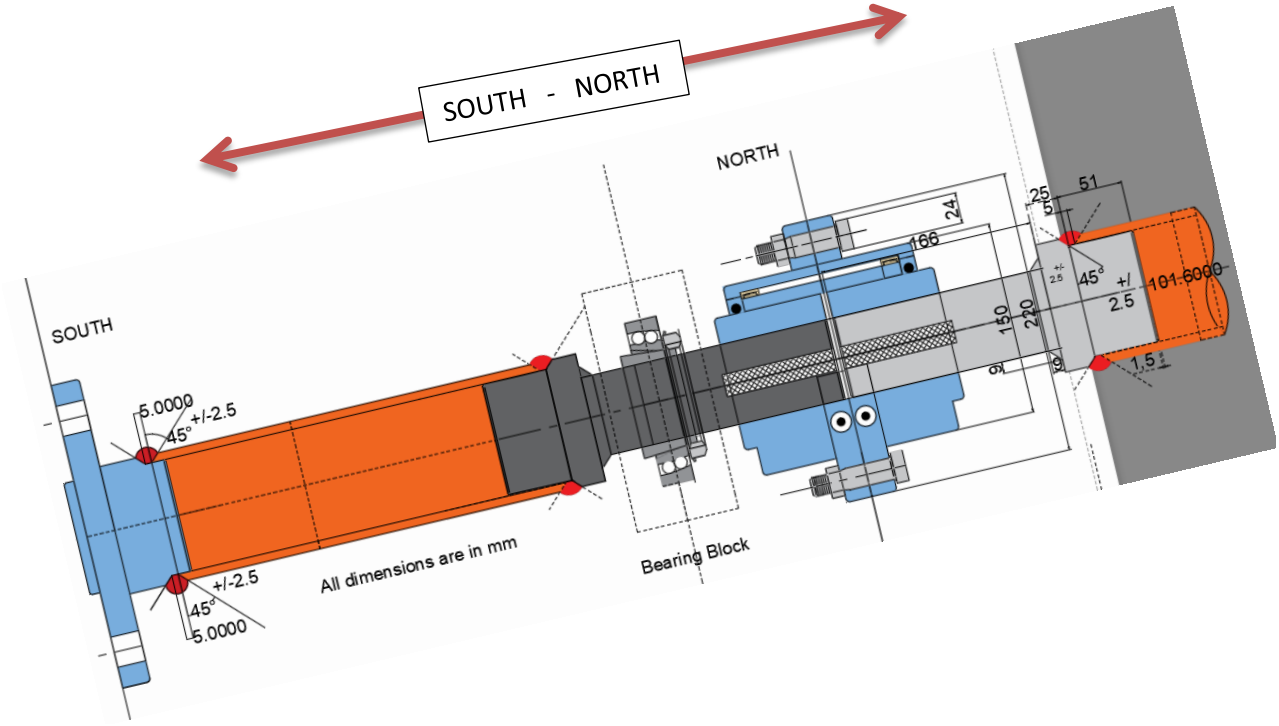
36) By using Zig Assembly drive pipe shaft assembly shall be lifted to its original position.

37) While fixing it, First Bearing outer Race shall be fitted into its plumber block slot with if any adjustment required, can be done by adjusting the lock nut.
Note: Lock washer extension shall be bend in lock nut slot during final installation time only

38) After proper fixing of bearing outer race inside the plumber block , Gear coupling outer south sleeve shall be bolted its north side sleeve without O ring after required alignment,

39) Rigid coupling north side hub shall be bolted with its south side hub with proper tightening.

40) After both end Fixed, By using Zig assembly with rope pulley arrangement and pipe Fit up clamp, alignment shall be done as per given below and followed by tag welding by using electrode EUTECTRODE 680.



41) After tag welding, Pipe fit-up clamp shall be removed from its position and both side coupling bolt shall be opened, then by using zig assembly north side portion shall be lifted first to remove bearing outer race from plumber block without any damage and followed by proper covering to avoid contamination.

42) Using zig assembly, complete fit up shall be shifted to ground level and same shall be moved to maintenance shed.

43) After fixing the Fit up assembly on fixed V block , Welding shall be done as per annexure B
Note: Heat treatment procedure shall be followed as per Annexure B

44) After Heat treatment process , shaft surface shall be made free from debris by using grinding polish wheel

45) As a final opportunity, all previously measured length shall be compared to new drive pipe shaft assembly.

46) Complete drive pipe shaft assembly shall be shifted to its ORT original location.

47) By using Zig Rope pulley assembly, drive pipe shaft assembly shall be lifted and followed by bearing outer race fixing inside its plumber block first.

48) After Bearing fixing, rigid coupling and gear coupling alignment shall done

49) After Alignment, rigid coupling shall be bolted with lock nut and lock pin

50) Same like, Gear coupling south side outer sleeve shall be bolted with north side inner sleeve with O ring on both side.

51) After both coupling complete alignment and box up, bearing lock nut shall be tightened in adequate level and followed by its lock washer square extension bend into lock nut any one of the its slot.

52) With proper Grease fill up inside plumber block, top sleeve shall be closed and followed by plumber block final bolt tightening, Rain protection cover box up.

53) Trail rotation shall be taken from west to east and east to west limit in both slew and track mode.

54) Differential synchro error voltage shall be measured during trail rotation and its should be jointly witnessed by both electrical and mechanical team.

55) After trail rotation found satisfactory from both mechanical and electrical department, ORT shall be brought to its west limit to measure Q height reading.
Note: Difference between previous measured Q height readings and new Q height readings shall be not greater than 15mm.Now this measured Q height reading shall be considered as new reading for future.

56) For further steps, respective system SOP shall be followed (synchro, Encoder or mis-alignment loop).

VIII. Do's & Dont's

Do's:

a) Measurement can be done only by steel measurement inch tape.

b) Electrode storage shall be done in portable oven.

c) Only grinding machine shall be used for cutting purpose.

d) Coupling bolts shall be checked for any shear/crack before reuse.

e) Any stub shaft having external undercut at any stage shall be rejected.

f) After drive pipe shaft replacement Q reading shall be taken for comparison.

g) Painting shall be done before final installation of assembly shaft

Dont's

a) Civil elastic inch tape or steel scale shall not be used for measurement.

b) Nonstandard surface shall not be used for alignment and run out checking purpose.

c) Root gap shall not be more than 5mm.

d) Direct current Electrode negative (DCEN) shall not be used.

e) Oxy-acetylene torch shall not be used for cutting purpose.

f) Drive pipe shaft having deflection shall not be used for replacement.

IX.ANNEXURE-A

DESCRIPTION	REMARKS
1) CUT LOCATON **(schematic drawing to be attached)**	
2) Reason for drive pipe shaft CUT	
3) Possibility to avoid in future	

X.ANNEXURE-B

Welding Procedure Specification

WELDING PROCEDURE SPECIFICATION (WPS)

			Identification #		
			Revision	1	Date		By	SRIRAM P
Company Name	RAC-NCRA		Authorized by	Sh.SRM	Date	
Welding Process(es)	SMAW		Type---Manual	MANUAL		
Supporting PQR No.(s)	-					

JOINT DESIGN USED

Type:	GROOVE
Single	YES
Backing:	No
Backing Material:	NO
Root Opening	2.5-3
Groove Angle	37.5 +/- 2.5
Back Gouging:	NO

POSITION

Position of Groove:	-	Fillet:	F,H.V.OH
Vertical Progression:	UPHILL		

ELECTRICAL CHARACTERISTICS

Transfer Mode	SMAW
Current:	AC / DCEP

BASE METALS

Material Spec. EN9 to SAE4140

	C%	Mn%	P%	Si %	Cr%	Mo%
EN9	0.5-0.6	0.6-0.9	0.04	0	0	0
SAE4140	0.38-0.43	0.75-1	0.035	0.15-0.35	0.8-1.10	0.15-0.25

FILLER METALS

AWS Specification	-
AWS Classification	-

SHIELDING

Flux	-	Gas	-
		Composition	-
Electrode-Flux (Class)		Flow Rate	-
		Gas Cup Size	-

TECHNIQUE

Stringer or Weave Bead:	WEAVE		
Multi-Pass or Single Pass (per side)	MULTI PASS		
Number of Electrodes	-		
Electrode Spacing		Longitudinal	-
		Lateral	-
		Angle	-
Contact Tube to Work Distance	-		
Peening	-		
Interpass Cleaning:	-		

PREHEAT and INTERPASS TEMPERATURE

PREHEAT TEMPERATURE	250 deg C
INTERPASS TEMPERATURE	300 deg C
POST HEATING	
TEMPERATURE	300 - 350 deg C

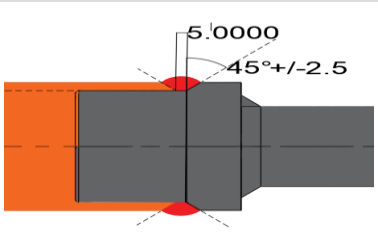
POST WELD HEAT TREATMENT

Soaking Temperature	
Rate of cooling & Heating	

WELDING PROCEDURE

Pass or Weld Layer(s)	Process	Filler Metals Class	Filler Metals Diameter	Current Type & Polarity	Current Amps
	SMAW	EUTECTRODE 680	1.6	AC	60
	SMAW	EUTECTRODE 680	1.6	DCEP	60
	SMAW	EUTECTRODE 680	2.5	AC	70-90
	SMAW	EUTECTRODE 680	2.5	DCEP	70-90
	SMAW	EUTECTRODE 680	3.2	AC	90-130
	SMAW	EUTECTRODE 680	3.2	DCEP	90-130
	SMAW	EUTECTRODE 680	4	AC	120-180
	SMAW	EUTECTRODE 680	4	DCEP	120-180

Joint Details



Notes:

1) Edge shall be prepared as per given dimesnion
2) Electrode baking shall be done in 250 deg c for 2hrs and its shall be stored in 125-150 deg c.
3) Electrode storage shall be started 2hrs before the job.
4) Groove edge shall be free from contaminations
5) Root gap shall be more than 5mm
6) After Root pass and hot pass, Proper fusion of edges and no crack shall be ensured
7) At each pass, Flux shall be removed
8) External undercut shall not more than 1mm
9) After final pass, Excess peneration shall not be more than 2.56mm
10) post heating, shall be done by heating coil
11) Post heating shall be started immediate to weld completion.
12) During Post heating , weld shall be covered by Non conductive blanket
13) After postheating, Final weld shall be evaluated by DP test
14) Before painting , DP material shall be cleaned properly from surface.

XI ANNEXURE-C

TOWER NO	Q –Height READING (mm) (after rectification works) **Date:-**	Q –Height READING (mm)OLD (17-01-2019)	REMARKS
N12		5435	
N11		2170	
N10		2165	
N9		2040	
N8		1690	
N7		1895	
N6		2130	
N5		1800	
N4		1595	
N3		2180	
N2		2700	
N1		3305	
S1		3920	
S2		4450	
S3		3110	
S4		2790	
S5		2915	
S6		3242	
S7		3425	
S8		3125	
S9		2450	
S10		2035	
S11		2080	
S12		1650	

- **Q – Readings are found satisfactory and ORT can be operated.**
- **ORT is herewith released for observations.**

(Mechanical) **(Electrical)** **(Electronics)**