



भारत सरकार
रेल मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION
FOR
FIBRE REINFORCED PLASTIC (FRP) AXIAL FLOW RADIATOR FAN
FOR
WDM2 / WDM2C / WDG2 / WDP2 & WDP1 LOCOMOTIVES

SPECIFICATION NO. MP- 0.05.00.02 (Rev.-0.00)
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TECHNICAL SPECIFICATION FOR FIBRE REINFORCED PLASTIC (FRP)
RADIATOR FAN
FOR
WDM2/ WDM2C/ WDG2/ WDP2 & WDP1 LOCOMOTIVES

1.0 SCOPE :

This specification covers the design, material, manufacturing inspection and testing requirement for engine cooling system FRP AXIAL FLOW *RADIATOR FAN for WDM2/WDM2C/WDG2/WDP2 & WDP1* class locomotives, built by Diesel Locomotive Works, Varanasi, India. This FRP fan is under development as a replacement of the existing Aluminium fan.

1.1 SCOPE OF SUPPLY:

FRP radiator fan complete with hub and its fasteners to the latter.

2.0 SYSTEM DESCRIPTION :

- 2.1 The radiator fan is a device which sucks the atmospheric air through the radiator panels & expels it to atmosphere to cool the engine coolant after discharge from the engine and maintains an acceptable operating temperature by transferring heat from the engine to the atmospheric air.
- 2.2 The radiator fan assembly is fitted at the rear end of the locomotive, which takes drive from the engine through horizontal shaft, Eddy Current Clutch gear box & Universal shaft arrangement. There are two speed of radiator fan depending upon the temperature of cooling water. At water temperature of 68 deg. C the radiator fan starts rotating at a slow speed . The radiator fan rotates at its full speed approximately 1210 RPM (2600 h.p. locomotive) and 1260 RPM (3100 h.p. locomotive) for 1000 RPM & 1050 RPM of engine respectively when the water temperature reaches 74 deg. C .
- 2.3 The radiator fan assembly consist of a hub with six blades screwed on its periphery and is mounted on the fan shaft & bearing housing assembly. It is driven by a universal shaft through a Eddy Current Clutch and right angle gear box unit which transfers the power from horizontal to vertical direction & raises the speed of the shaft in the ratio of 1: 1.312.
- 2.4 The radiator fan of the diesel engine is a very critical component of the diesel locomotives, on which depends the health of the diesel engine and prolonged full load operation of the locomotive. The radiator fan of the diesel locomotives is required to work in a very hazardous environment with ingress of oil, dust and rain. It can be exposed to the roadside dust or fibre of various organic materials that can be in the environment of the locomotive operation. such as:

- a. Calcium Carbonate
- b. Silica sand .
- c. Aluminium.
- d. Carbon black
- e. Fibre of various organic Materials
- f. Oil.
- g. Locomotives brake shoe dust

The vibrations level encountered are also very high.

3.0 **DIMENSIONS & TOLERANCES:**

- 3.1 The outline and general arrangement of the FRP radiator fan assembly shall conform to RDSO drawings no. SKDP 3593 given in Appendix-1.
- 3.2 The FRP radiator fan and its hub shall be interchangeable with the complete aluminium fan assembly to DLW Drg. No. TPL - 0165 (Sheet 1 OF 7).
- 3.3 The mounting of fan blade on the hub shall be done by fastening with blocks and nut bolts. Alternatively, the mounting shall be suitably modified to enable fitment rigidly with the hub. (Drg. No. 3597) may be referred. The fan hub shall be die cast & conform to cast aluminum alloy to B.S. 1490-1988 Grade LM - 6 OR I.S. - 617 , Grade A-6.
- 3.4 The manufacture shall prepare their own drawing based on these guidelines . These drawing shall be submitted for approval to RDSO before the manufacture of prototype.

4.0 **MATERIAL:**

- 4.1 FRP radiator fan shall be manufactured from Isophthalic resin reinforced with a combination of E - glass unidirectional roving, chopped strand mat and woven roving either by RTM (Resin Transfer moulding) or compression moulding process. FRP radiator fan shall be free from , blow holes, pinholes , porosities etc.
- 4.2 Catalyst pigment and accelerator should suit the above resin. The colour of the pigment shall be either blue or green. The glass reinforcement used shall not be less than 35 % in content.
- 4.3 The above resin has been specified to obtain high tensile and flexural strength, in view of the fact that the standard deviations of tensile strength in FRP is very high. However the resin and reinforcement has to be chosen such that the mechanical properties specified in this specification are met. The manufacture is free to offer an alternative glass reinforced plastic material. In such a case not only shall, the manufacture submit the resin , reinforcement and process details but also attach a write-up establishing the suitability of the material offered.

5.0. **PROPERTIES AND TESTS :**

5.1. The manufacturer shall supply test pieces of size 300mm x 300mm and 4 ± 0.5 mm thickness constructed using the same material, process and facilities as for the FRP radiator fan. These test specimens shall be used for type tests as well as routine/acceptance tests as stipulated in this specification unless this specification calls for a different size or method of preparation of the sample.

5.2 **PHYSICAL PROPERTIES :**

Sl No.	Properties	Specified Values	Method of Test	Type Test	Acceptance Test
1.	Specific gravity	1.5	I.S.10192-1982	√	X
2.	Dimensional check	As declared	--	√	√
3.	Hardness Rockwell (min.)	As declared	I.S.1998-1962	√	√
4.	Tensile strength Kgf/cm ² .	800	I.S.1998-1962	√	√
5.	Flexural strength Kgf/cm ² .	1000	I.S.1998-1962	√	√
6.	Compressive Strength Kgf/cm ² .	1600	I.S.1998-1962	√	√
7.	Shear strength kgf/cm ² .	400	I.S.1998-1962	√	√
8.	Water absorption at = (27±2 deg.C for 24±0 hrs.)	0.8%	I.S.1998-1962	√	X
9.	Min. Fibre content	35 %	Appendix-2	√	X
10.	Max. Fibre length	As declared	Appendix-2	√	X
11.	Resistance to boiling water	Shall pass the test	Appendix-3	√	X
12.	Material composition of fan hub	Cast Al Alloy (LM- 6)	BS 1490 -1988, Grade 6 or IS - 617, Grade A-6	√	X
13.	Radiography of hub	As per IS 617 : 1994 clause 7.2.2		√	√

6.0 **PERFORMANCE REQUIREMENTS:**

- 6.1 The radiator fan assembly to be supplied shall meet the air flow requirements given in the table appended below (refer RDSO GDP NO. 1102 copy enclosed) with the provision that the air flow shall not be less than the specified by more than 1.5% at any point. The rating point requirement of airflow & power consumed shall, however, either be fully met or excelled.

S No.	Description	2600 HP	3100 HP
1.	Speed (rpm)	1200	1260
2.	Total pressure (mm of water)	82 mm	88.5 mm
3.	Air flow rate (1000 cfm)	119	125.6
4.	Power absorbed at design point (HP)	90.6 h.p.	98.5

7.0 **INSPECTION AND TESTING:**

The tests to which the complete equipment shall be subjected to are-

7.1 **Type Tests**

These tests shall be carried out on the prototype submitted for approval and thereafter @ one locomotive set of equipment for each 50 sets or part thereof. If there is any change in the design or source of supply of any component/sub-assembly, sets made of changed design or new source shall be treated as separate batch for the purpose of type test.

7.2 **Acceptance Tests**

These tests shall be carried out on all the sets of equipment of each order.

S.N.	Test	Description	Type	Acceptance
1.	Visual Examination	Blades shall be checked for finish, moulding blow holes, pin holes and porosities defects hub shall be checked for finish, casting and surface defects.	√	√
2.	Dimensional Examination	Blades shall be checked for finish, moulding blow holes, pin holes and porosities defects hub shall be checked for finish, casting and surface defects.	√	√
3.	Balancing	Fan assembly shall be statically and dynamically balanced as per I.S.O. 1940, Grade G.6.3. For balancing material shall be removed/added as specified in the specification. Match marks should be provided on the balanced blade and hub after balancing.	√	√

S.NO.	Test	Description	Type	Acceptance
4.	Spin Test	The radiator fan assembly shall be subjected to spin test at a speed 5% more speed than max. working speed of 1325 rpm (min) for a duration of 15 minutes . The frequency of spin test shall be done out of ten assemblies. The blades shall not show any signs of cracks or visible structural deformations after test.	√	√
5.	Performance test	The manufacturer / supplier shall arrange for performance test of the prototype fan either at its works or elsewhere in terms of air flow, pressure rise and power consumption. The air flow and pressure rise shall be tested in accordance with BS.848, Part I, 1980. or ANSI / AMCA-210-85 STANDARDS.	√	X

7.3 The inspecting authority shall have free access to the manufacturing and testing facilities available at firm's premises or at his sub contractor's premises during the course of manufacturing and testing of the units.

7.4 **GENERAL CONDITIONS OF INSPECTION :**

Complete system or part thereof including fittings used during manufacture shall be inspected by the Inspecting Authority nominated for the purpose. The manufacturer shall make available necessary test facilities and equipment required for inspection, free of cost. The manufacturer shall also supply test certificate of the system/parts procured from his vendors and used in the equipment supplied to the purchaser.

8.0 **Quality Assurance:**

The manufacturer/supplier shall supply quality assurance programme (QAP) being followed by them and shall get the same approved by the purchaser after prototype is approved and before taking up series production.

9.0 **FIELD TRAILS :**

After successful completion of the type tests the radiator fan assembly shall be subjected to field trails for a period not less than six months before commencement of series production. During this period, the performance of the equipment shall be closely monitored and evaluated by RDSO. These trials are intended to prove-

- Reliability under rigorous environmental and operating conditions.
- Advantages for locomotives operation and maintenance.
- Maintainability of the equipment.

Modifications found necessary as a result of the test / trials shall be carried out by the supplier at his own cost after relevant modifications have been jointly agreed between RDSO & supplier.

The supplier shall render necessary assistance in the installation and commissioning of the prototype system for field trials.

10.0 **INSTALLATION OPERATING & MAINTENANCE INSTRUCTIONS :**

The supplier shall furnish detailed installation, operating and maintenance instructions with illustrative diagrams for guidance of the purchaser. One copy of such instructional bulletin shall be supplied with each set of equipment.

11.0 **WARRANTY:**

The manufacturer/supplier shall give a warranty of twelve clear months from the date of commissioning of the assembly on a locomotive. If any unsatisfactory performance is observed during the warranty period, the manufacturer/supplier shall arrange for necessary repairs/replacements at site, free of charge, by the manufacturer free of cost. Such replaced components shall further be under warranty for 1 year from the date of decommissioning.

LIST OF DRAWINGS, RDSO LKO

S NO.	DESCRIPTION	DRG. NO.
1.	Radiator fan assly.	SK.DP. 3593
2.	Radiator fan hub	SK.DP. 3594
3.	Center bush for hub	SK.DP. 3595
4.	Radiator fan blade	SK.DP. 3596
5.	Blade holding block	SK.DP. 3597

FIBRE CONTENT AND FIBRE LENGHT

1. This test is specified by RDSO for SMC. The method may not suit the resin / reinforcement offered by the manufacturer. In such a situation the manufacturer shall suggest the test method which shall be adopted with the purchaser's approval.
2. At least two specimens cut out from two different laminates as per clause 4.2 shall be selected for checking of fibre content. All weighing shall be to the nearest 0.01 gm.
3. Specimen of size 75 x 75 mm shall be cut from the corners of the square laminates.
4. A silica dish of appropriate dimensions shall be heated in a muffle furnace at 575 ± 25 Deg. C for 15 min. , cooled in a desicator and weighed (W1). The test specimen shall then be placed in the dish and the whole unit heated at 105 Deg. C for 2 hours, cooled in a desicator and weighed (W2).
5. The sample with dish shall then be heated in a ventilated muffle furnace at a temperature of 575 ± 25 Deg. C for 30 minutes, cooled in a desicator and weighed (W3). This process is repeated until the difference in weight in successive weighing is less than 0.01 gm.
6. The contents in the dish shall be treated with concentrated hydrochloric acid and the acid shall be removed by washing. The contents remaining in the dish shall then be dried at 105 Deg. C for 2 hours and weighed (W4) . This process shall be repeated until the difference in weight is less than 0.01 gm. The lenght of fibre selected from the Center of the sample on the dish away from cut edges shall be measured and recorded . The content shall be examine to find whether filler particles still remain within the contents . If filler particles are not present, the fibre content shall be calculated as follows:-

$$\text{Fibre content (\%)} = 100 \times \frac{(W4 - W1)}{(W2 - W1)}$$

The approximate filler content shall be as follows:

$$\text{Filler content (\%)} = 100 \times \frac{(W3 - W4)}{(W2 - W1)}$$

RESISTANCE TO BOILING WATER

1. This test is to assess the amount of water absorbed in boiling water and soluble matter and to serve as an accelerated weathering test.
2. Three test specimens used for measuring cross-breaking strength as per ASTM - D - 790 shall be prepared . The specimens shall be dried in an oven at 50+ 3 deg. C for 24 hrs. , cooled in a desiccator and weighed (W1) . These shall then be immersed in boiling distilled water for 4 hours . The specimens shall then be cooled for 15 minuets in water at room temperature and dried with a clean cloth or filter paper and weighed (W2).
3. The specimen shall then be redried in an oven at 50+3 deg.c for 24 hours, cooled in a desiccator and weighed (W3). The percentage of water absorption

$$= 100 \times (W2 - W3) / W1$$

the percentage water soluble matter = 100 x (W1 - W3) / W1
4. The specimens shall then be tested for cross - breaking strength as per ASTM D-790 (say CBS-2) and percentage reduction computed against the value obtained with the original sample (cross breaking strength , CBS-1)

$$\text{Percentage reduction} = (CBS-1 - CBS-2) / CBS-1$$

5. **Requirements**
 - 5.1 The test specimens shall not show any warping, cracking or in strength change in appearance .
 - 5.2 The percentage of water absorbed (average of three measurements) shall be less than 2% .
 - 5.3 Percentage of water soluble matter shall not exceed 0.1%.
 - 5.4 The percentage reduction in CBS (Cross-Breaking Strength) after boiling in water for 4 hours shall not be more than 20%.

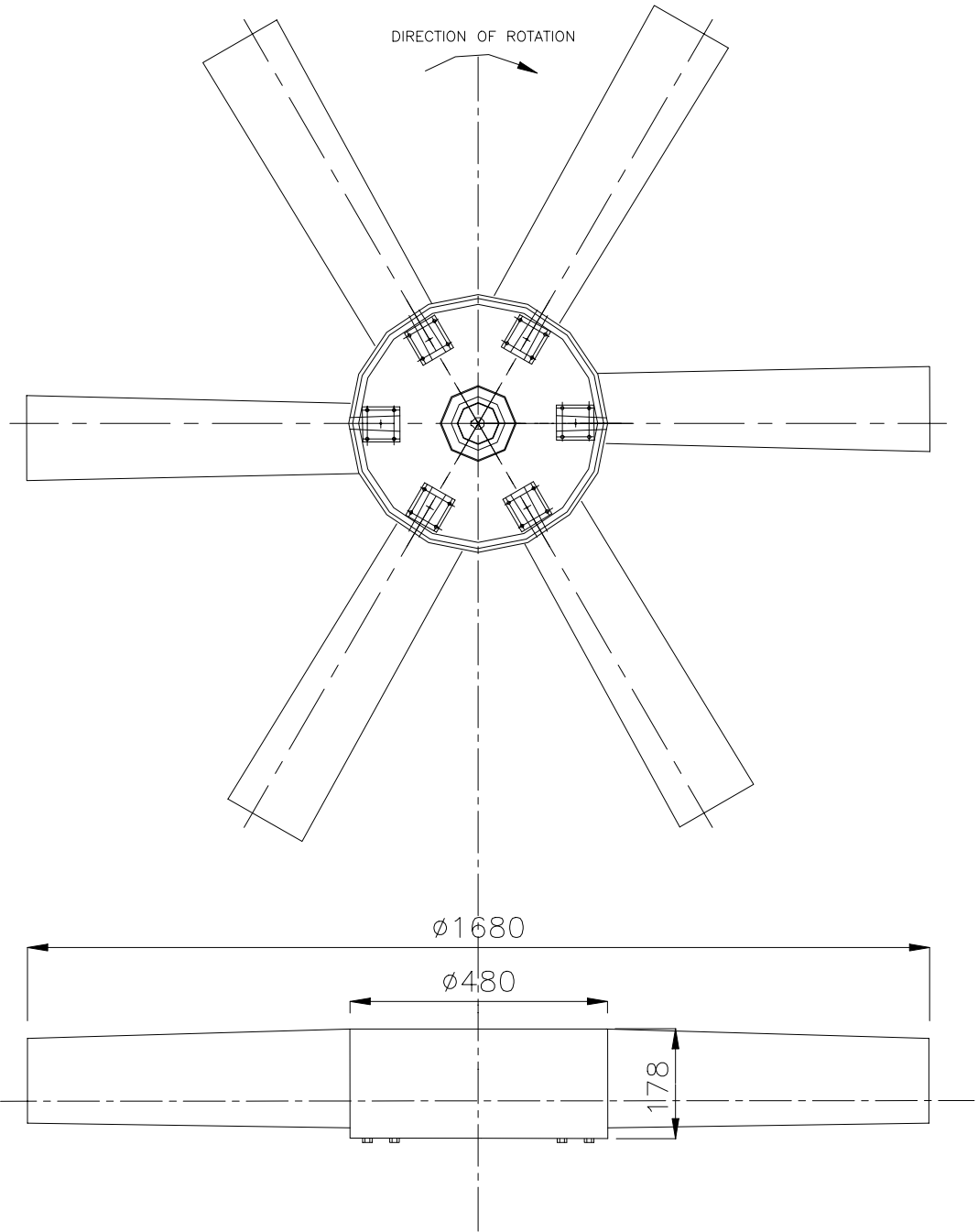
RESISTANCE TO SPREAD OF FLAME

1. The test for resistance to spread of flame shall be carried out in the following manner.
 - (i) Test specimens of the material measuring about 150 mm x 50 mm and 4+0.5 mm thick shall be subjected to the luminous flame from a bunsen burner of 10 mm ID. The specimen shall be held with both the longitudinal & transverse axes at an angle of 45 deg. to the horizontal as shown in fig. A & B . The flame height shall be 40 mm and the bottom edge of the specimen shall be placed at the middle of the flame.
 - (ii) The flame shall be applied to the specimen at the end for 30 seconds and removed for a similar period and then applied again to the same end for a second period of 30 seconds and then again removed.
 - (iii) Should the specimen get ignited when tested in either way, it shall not continue to burn for more than 30 seconds after the flame has been finally removed.
 - (iv) The test shall be conducted with three test specimen for each test conditions as shown in Fig. A & B.

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APPLICABLE FOR

RADIATOR FAN ASSEMBLY



NOTE :-
1. ALL DIMENSIONS ARE IN mm.
2. ASSEMBLY WEIGHT 70 Kgs (approx).

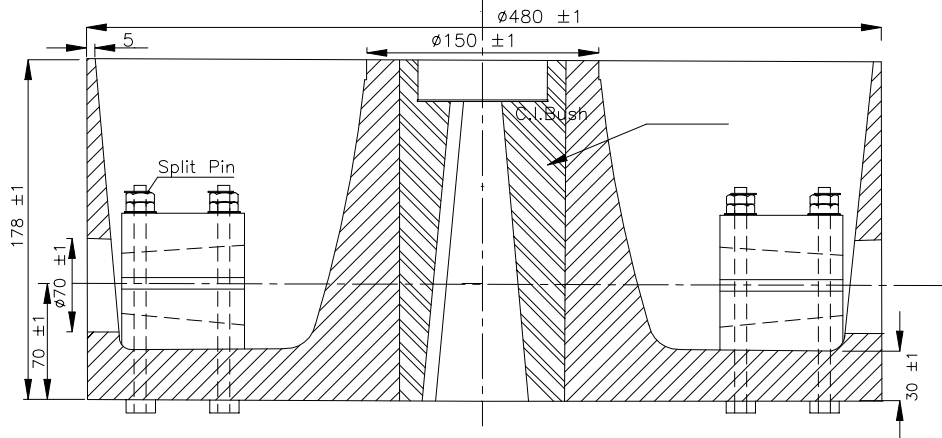
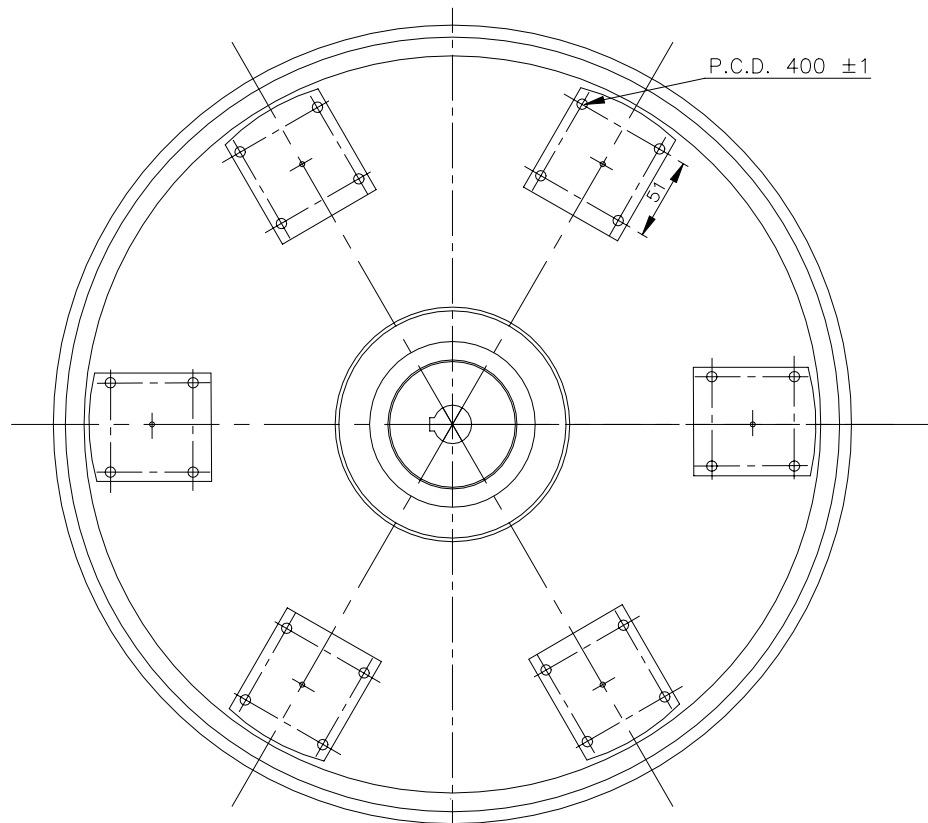
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HAND FILE	ROUGH MACHINING	FINISH MACHINING	GRINDING						
MATERIAL	-				DRG. No. SK.DP-3593				
ALT.	No. OF PLACES	REF. No.	DESCRIPTION		ALT. NOTE No.	SIGN.	DATE	FIRST ISSUED	SUPERSEDES

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APPLICABLE FOR

RADIATOR FAN HUB



NOTE :-
1. ALL DIMENSIONS ARE IN mm.

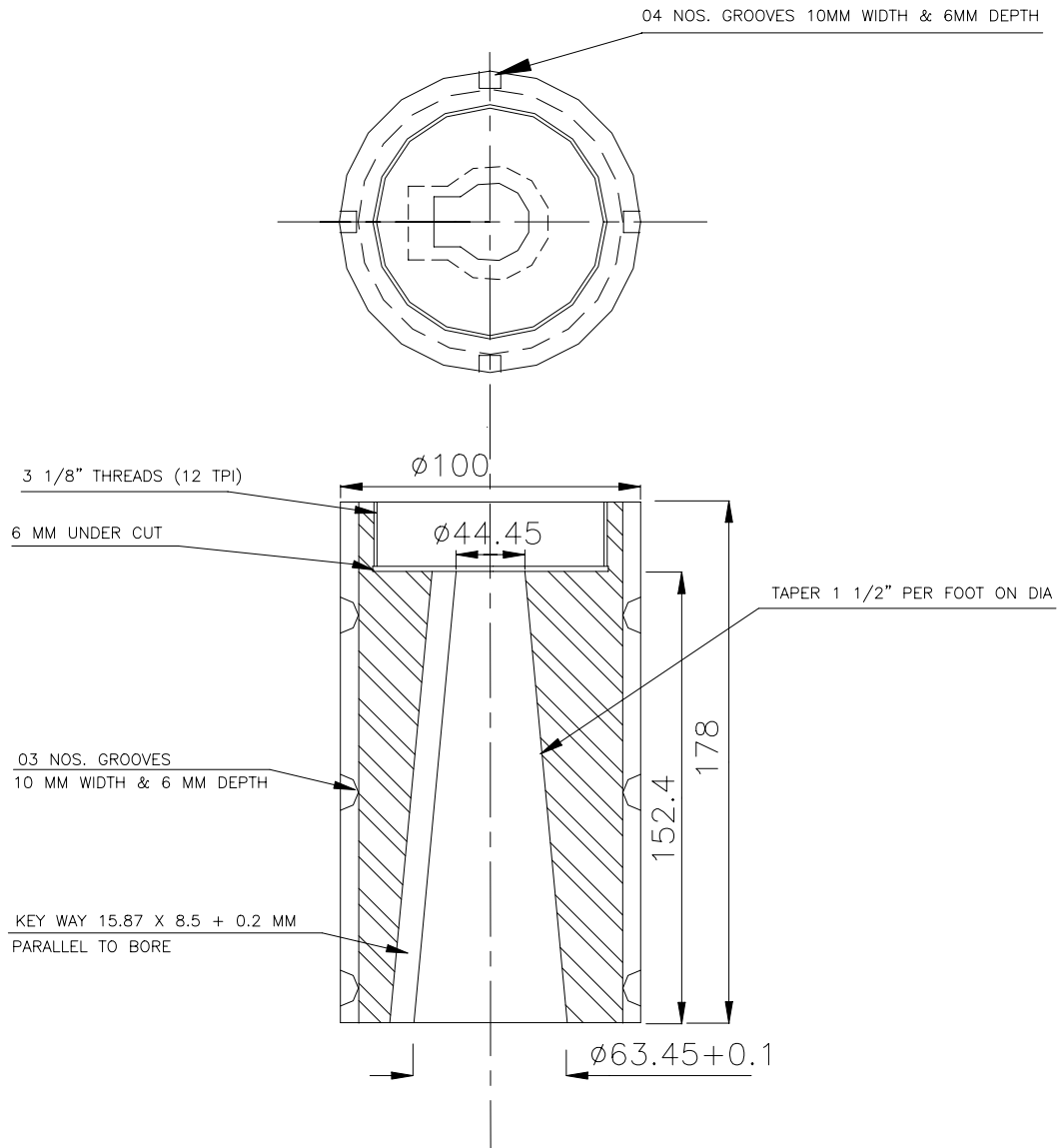
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HAND FILE	ROUGH MACHINING	FINISH MACHINING	GRINDING		
MATERIAL	LM-6				DRG. No. SK.DP-3594
ALT.	No. OF PLACES	REF. No.	DESCRIPTION	ALT. NOTE No.	SIGN.
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					FIRST ISSUED
					SUPERSEDES
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APPLICABLE FOR

CENTRE BUSH FOR HUB



NOTE:

- 1) All Dimensions are in mm.
- 2) Sharp Corners should be removed.
- 3) The Bush Bore Dimensions Dia 2.5", 1 1/2" Taper Per Foot.
- 4) Unspecified Tolerances are ±1.

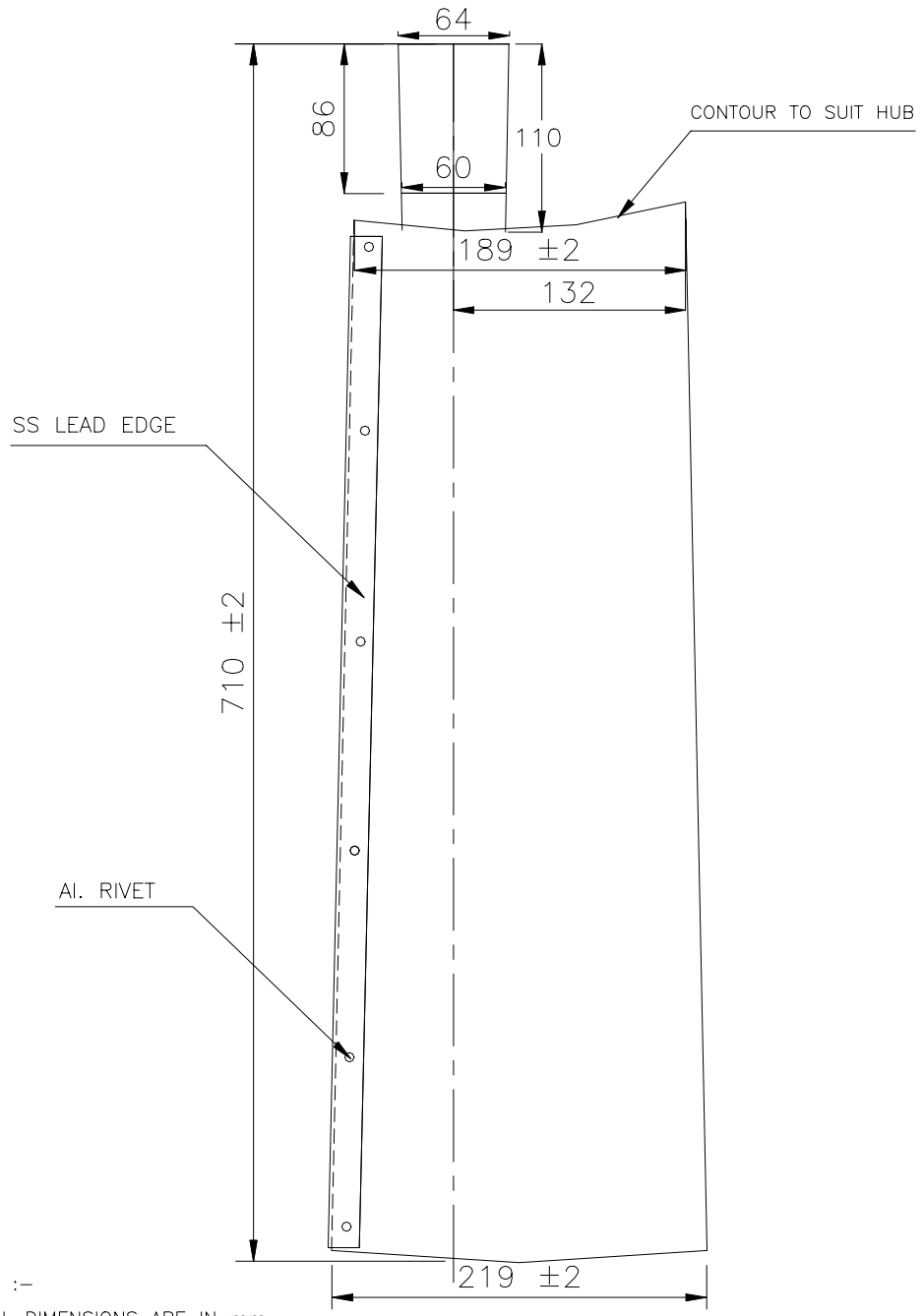
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HAND FILE	ROUGH MACHINING	FINISH MACHINING	GRINDING		
MATERIAL	F.G.-200				
ALT.	No.OF PLACES	REF. No.	DESCRIPTION	ALT.NOTE No.	SIGN.
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				FIRST ISSUED	DRG. No. SK.DP-3595
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APPLICABLE FOR

RADIATOR FAN BLADE



NOTE :-

1. ALL DIMENSIONS ARE IN mm.
2. UNSPECIFIED TOLERANCE ± 1

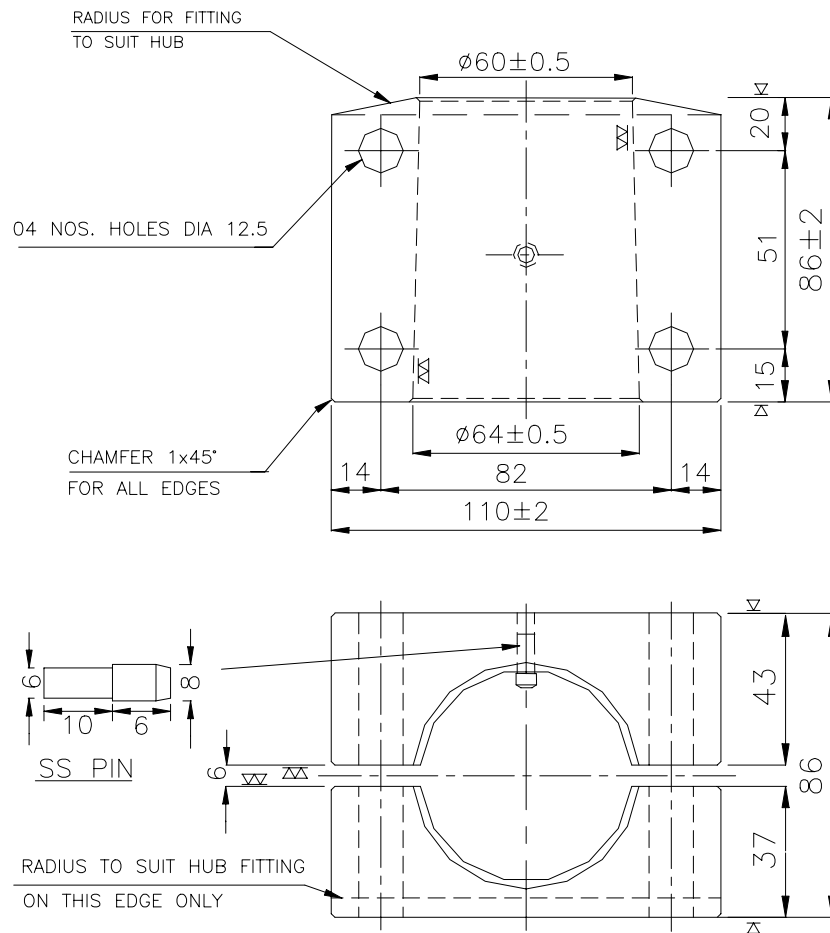
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HAND FILE		ROUGH MACHINING		FINISH MACHINING		GRINDING			
MATERIAL		FRP							
ALT.		No. OF PLACES		REF. No.		DESCRIPTION		ALT. NOTE No.	
SIGN.		DATE		FIRST ISSUED		SUPERSEDES		SUPERSEDED BY	
						DRG. No. SK.DP-3596			

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APPLICABLE FOR

BLADE HOLDING BLOCK



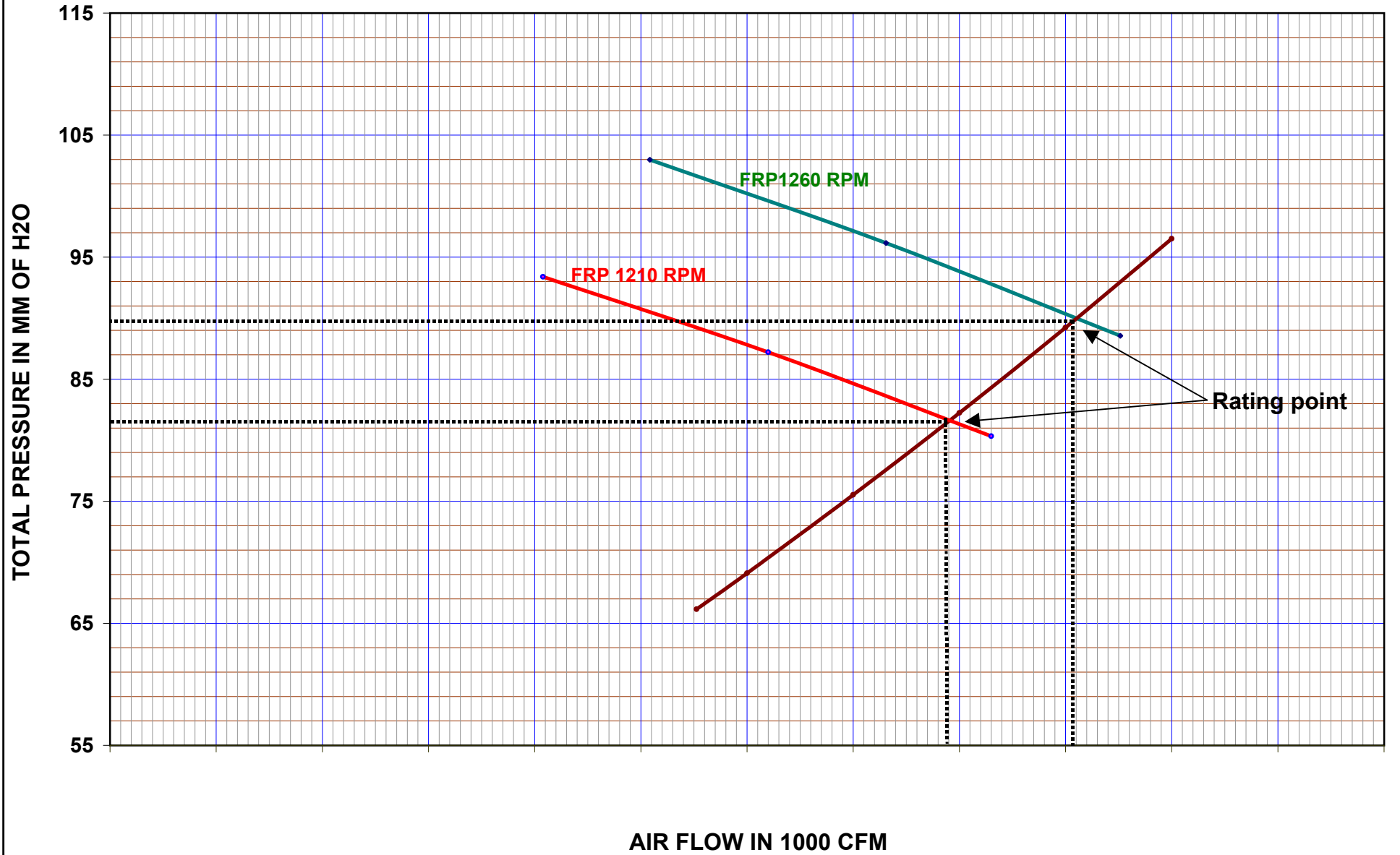
NOTE :-

- 1) ALL DIMENSIONS ARE IN mm.
- 2) REMOVE SHARP CORNERS.
- 3) UNSPECIFIED MACHINING TOLERANCE ±1

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HAND FILE	ROUGH MACHINING	FINISH MACHINING	GRINDING		
MATERIAL	LM-6				DRG. No. SK.DP-3597
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FRP FAN CHARACTERISTICS

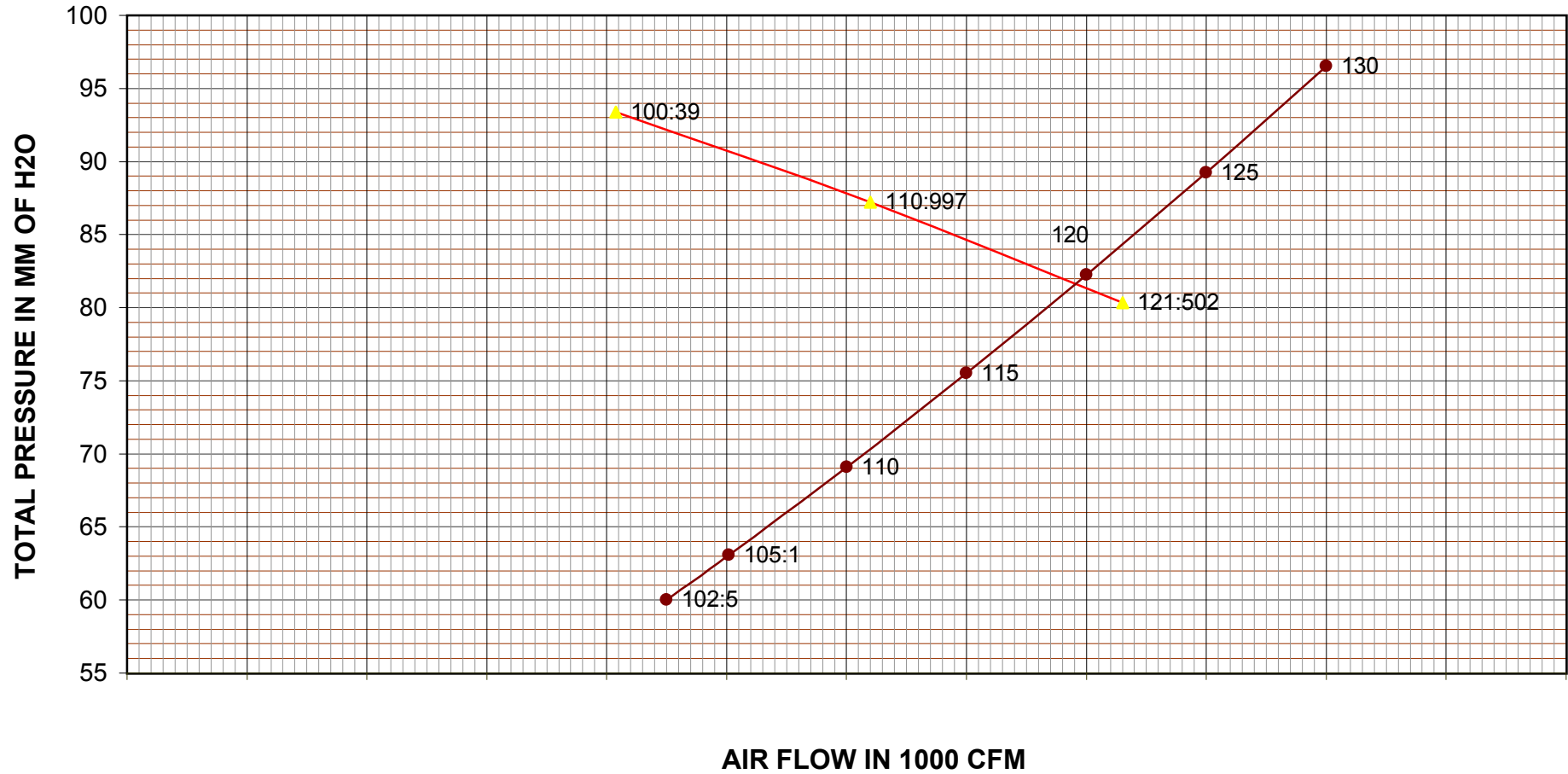


Drawn by :
Checked by :
Appvd. by :

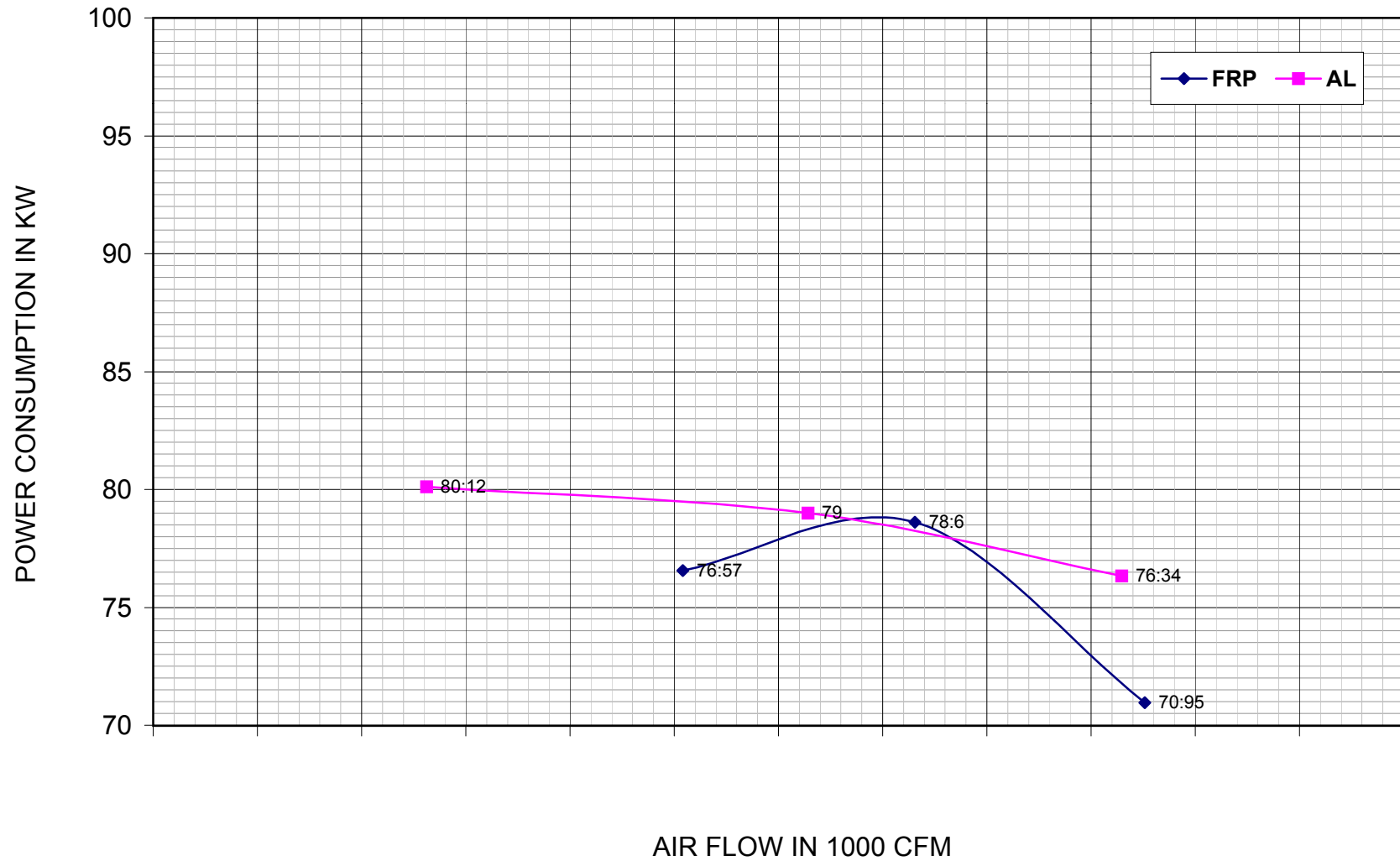
Ref :
R.D.S.O.(MP)
GDP - 1102

ALUMINIUM FAN TEST DATA AT 1200 RPM

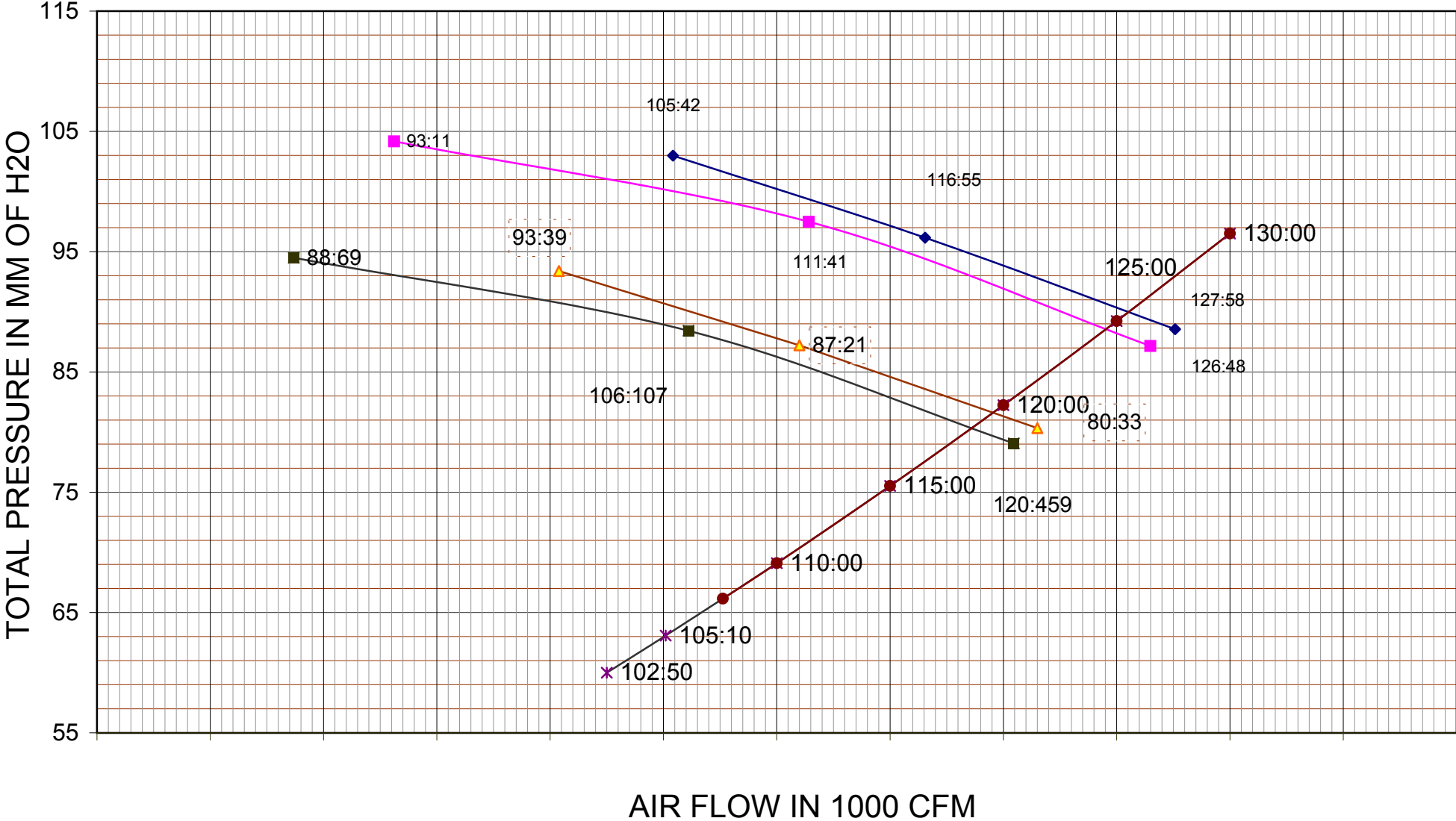
FPR1200 RATING POINT1200



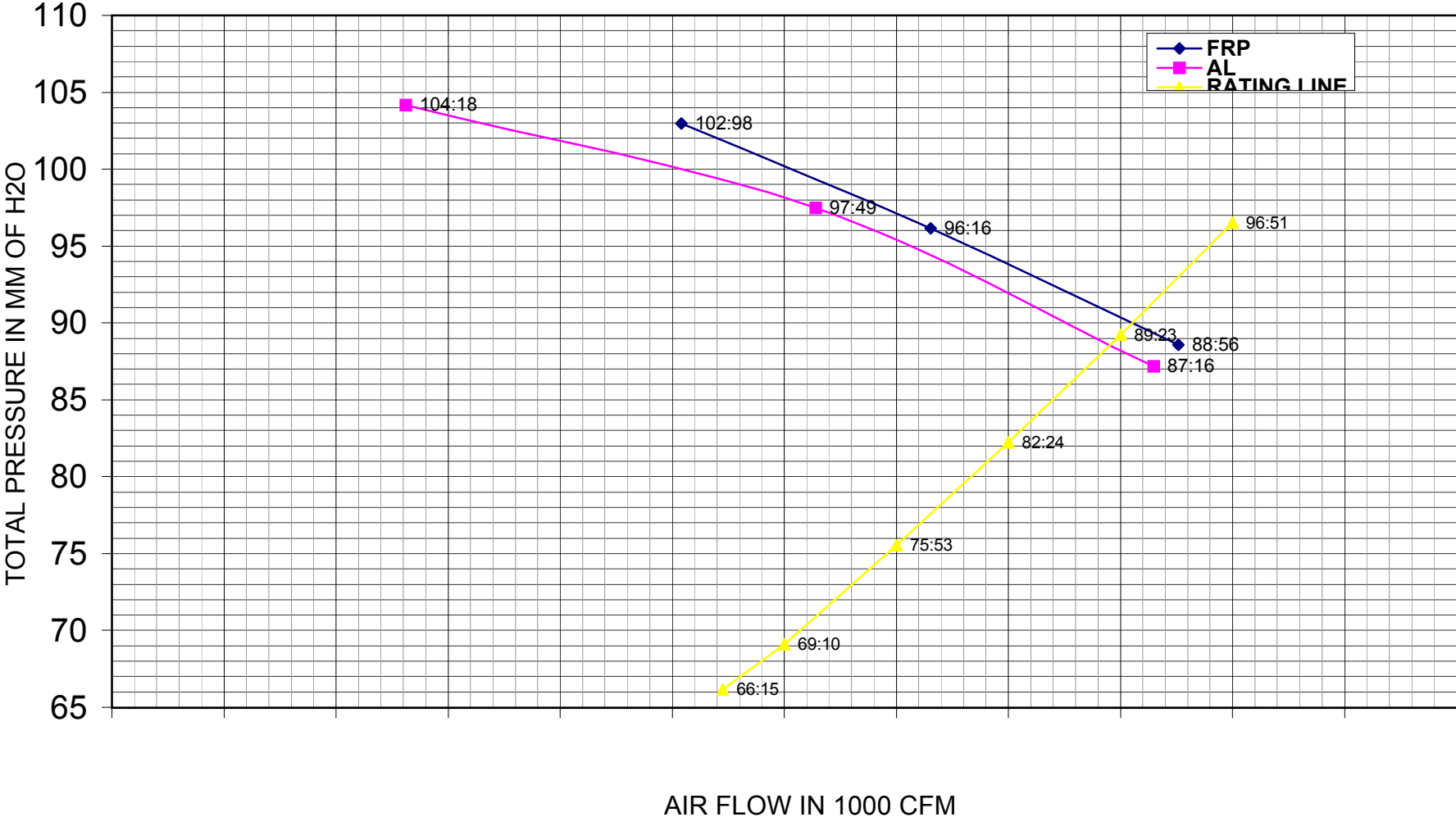
FRP VS ALUMINIUM FAN TEST DATA



FRP VS ALUMINIUM FAN TEST DATA



FRP VS ALUMINIUM FAN TEST DATA AT 1260RPM



Note:

The drawing Drg. No TPL- 0165 (Sheet 1 of 7) are missing.
Blue print of above mentioned drg. may be collected from RDSO.