BRUSH SEAL FOR STEAM GLAND

1.0) APPLICATION / SCOPE: This standard specifies the requirement of brush seal to be used in intermediate steam gland and balance piston gland of steam turbine.

2.0) **GENERAL TECHNICAL REQUIREMENT OF BRUSH SEAL:**

The brush seal is typically made of three components i.e. Front plate, bristle packing, backing plate. The mechanical design of brush seal is in vendor scope. As the brush seal requires minimum 5 years service life, the material selection and mechanical design part shall consider the structure integrity of front, backing plate and the bristle packing, material creep, High cycle fatigue etc. The Bristle material must exhibit high temperature strength, good oxidation resistance, and low wear rate so that seal effectiveness is maintained minimum for 5 years.

3.0) ORDERING NO. & CODIFICATION :

VAR NO.	BRUSH SEAL MEAN DIA	MATERIAL CODE	Technical requirement details
01	775	TC9751349010	Refer to Annexure - I
02	1175	TC9751349028	Refer to Annexure - II
03	762	TC9751349036	Refer to Annexure - III
04	1110	TC9751349044	Refer to Annexure - IV

4.0) GUARANTEE CERTIFICATE :

A guarantee certificate for 24 months of trouble free performance from the date of shipment or 12 months from date of commissioning whichever is earlier shall be furnished BHEL standard No. and Purchase Order No. shall be mentioned in the certificate.

5.0) DOCUMENTS :

Technical literature, Cross sectional drawing, Design calculations shall be accompany the offer.

6.0) MARKING :

6.1) A tag bearing relevant 12 digited material code of BHEL and purchase order No. shall be attached.

6**.2)** Following details shall be marked on packing case.

A) Manufacture's name/Supplier's name
B) BHEL purchase order No.
C) BHEL standard No. TC 51349.

7.0) Reference list :

The supplier shall provide the reference list for the brush seal supplies in the application area of Steam Turbines.

Note to Supplier:
Location of brush seals shown in the figures against each variant is indicative only. Supplier has to suggest the optimum location (seals together or separated by labyrinth fins) for minimum leakage across the gland.

Note:
The design and supply of total brush seal assembly and its associated parts are in the scope of the vendor. The vendor shall clearly furnish all the calculation and mating dimensions and details to be maintained by BHEL for both stator and shaft. The design is to be approved by BHEL.

ANNEXURE - I

Variant: 01

TECHNICAL REQUIREMENT OF BRUSH SEAL MEAN DIA 775 (Refer Fig-1)

1	Design Life	Minimum operating life of the brush seal shall be 5 years assuming 200 start up and shut down cycles per year. The total minimum life is 42500 hours
2	Material	Brush seal (Fig.1) including its components to withstand a temperature of 538 Deg. C (max.). The bristle material shall be preferably Haynes 25 and supplier to furnish the material selected along with offer
3	Shaft Diameter	Dia. 771 h9 mm (Base Diameter) Dia. 775 (mean Dia. Of gland)
4	Total Length of Steam Gland (Stator)	461.0 mm
5	Total No of 'See-through' Labyrinth fins ahead of brush seal	59
6	Pitch of the labyrinth fins on stator	5.7 mm
7	Pitch of the labyrinth fins on rotor	3.35 mm
8	Direction of Rotation of Shaft	Counter-clockwise when seen in the steam flow direction (up-steam to downstream)
9	Rotational speed of Shaft	3000 rpm
10	Material of Shaft	30CrMoNiV511
11	Inlet Pressure/ Temp. (Normal/ Max.) of intermediate gland	112 ata/ 516 Deg. C (Normal) 119 ata/ 523 Deg. C (Max.)
12	Outlet Pressure/ Temp. (Normal/ Max.) of intermediate gland	38 ata/ 480 Deg. C (Normal) 41 ata/ 486 Deg. C (Max.)
13	Leakage Quantity through intermediate gland	4.3 tons/hr
14	Radial clearance of bristle packing	To be provided by vendor considering rotor excursion and rotor dilation and thermal expansion of brush seal at steady state and to be approved by BHEL

15	Steady state Rotor radial excursion	0.055 mm
16	Steady state Rotor radial dilation due to rotational speed	0.080 mm
17	Bristle wear	Bristle wear shall be estimated by vendor by Considering rotor excursion and rotor dilation and effective rotor-bristle tip clearance in steady as well as transient condition. The guidance for allowable value of the wear shall be taken from the leakage flow through effective Clearance after wear for design life as approved by BHEL
18	Transient Rotor radial excursion (During startup and shutdown)	0.33 mm
19	Transient Rotor radial dilation	0.016 mm
20	Effective reduction in clearance due to differential thermal expansion of rotor-stator for transient operation	0.24 mm
21	Total duration of transient operation for transient wear estimation	1000 hours
22	Radial clearance and dimensions of front and backing plate	To be decided by vendor however the minimum radial clearance shall not be less than 2mm to prevent hard rubbing considering maximum distortion of casing and maximum rotor transient excursion
23	No. of Rows of brush seal	To be decided by vendor and to be offered as a set.
24	Bristle wire diameter and packing density	To be decided by vendor, based on bristle stability and wear and to be mentioned in approval drawing.
25	Seal Radial stiffness	To be provided by vendor and approved by BHEL
26	Machining details of Stator for brush seal assembly	To be provided by vendor

SKETCH OF BRUSH SEAL MEAN DIA. 775 FOR VARIANT 01:

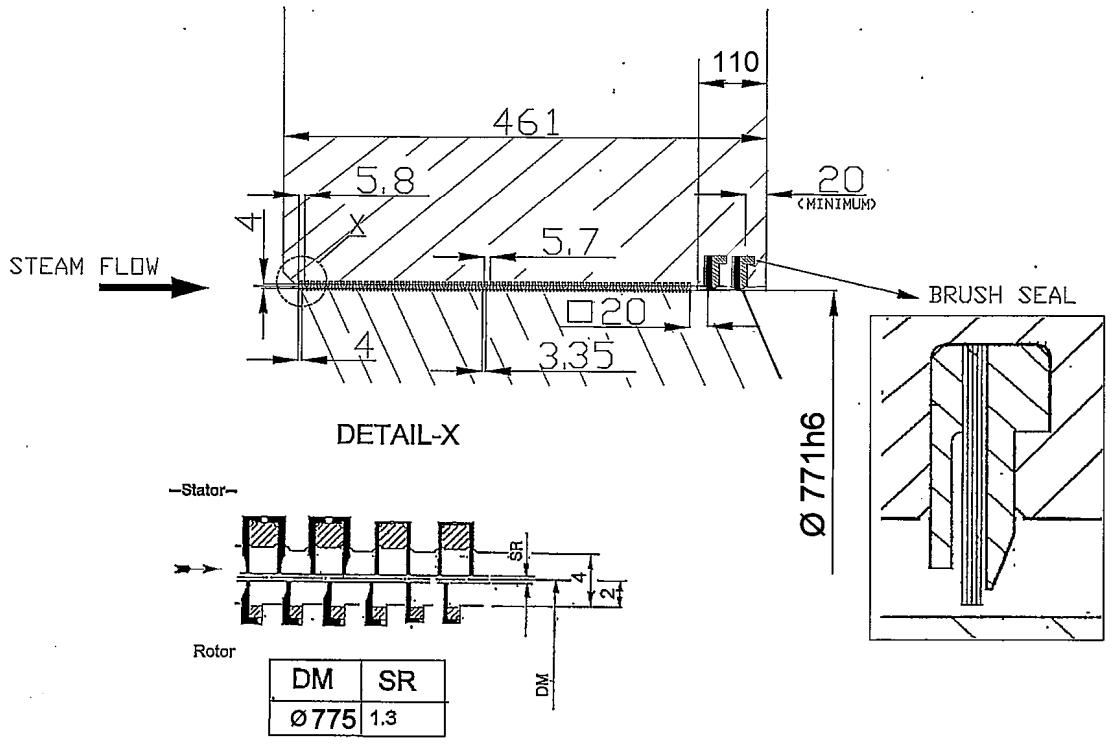

Fig. 1

ANNEXURE - II

Variant: 02

TECHNICAL REQUIREMENT OF BRUSH SEAL MEAN DIA 1175 (Refer Fig-2)

1	Design Life	Minimum operating life of the brush seal shall be 5 years assuming 200 start up and shut down cycles per year. The total minimum life is 42500 hours
2	Material	Brush seal (Fig.2) including its components to withstand a temperature of 430 Deg. C (max.). The bristle material shall be preferably Haynes 25 and supplier to furnish the material selected along with offer
3	Shaft Diameter	Dia. 1172 h9 mm (Base Diameter) Dia. 1175 (mean Dia. Of gland)
4	Total Length of Steam Gland (Stator)	301.0 mm
5	Total No of Labyrinth fins ahead of brush seal	25
6	Pitch of the labyrinth fins on stator	9.5 mm
7	Pitch of the labyrinth fins on rotor	9.5 mm
8	Direction of Rotation of Shaft	Clockwise when seen in the steam flow direction (up-steam to downstream)
9	Rotational speed of Shaft	3000 rpm
10	Material of Shaft	30CrMoNiV511
11	Inlet Pressure/ Temp. (Normal/ Max.) of intermediate gland	22 ata/ 350 Deg. C (Max.)
12	Outlet Pressure/ Temp. (Normal/ Max.) of intermediate gland	1.4 ata/ 328 Deg. C (Max.)
13	Leakage Quantity through intermediate gland	0.25 tons/hr
14	Radial clearance of bristle packing	To be provided by vendor considering rotor excursion and rotor dilation and thermal expansion of brush seal at steady state and to be approved by BHEL

15	Steady state Rotor radial excursion	0.082 mm
16	Steady state Rotor radial dilation due to rotational speed	0.025 mm
17	Bristle wear	Bristle wear shall be estimated by vendor by Considering rotor excursion and rotor dilation and effective rotor-bristle tip clearance in steady as well as transient condition. The guidance for allowable value of the wear shall be taken from the leakage flow through effective Clearance after wear for design life as approved by BHEL
18	Transient Rotor radial excursion (During startup and shutdown)	0.2 mm
19	Transient Rotor radial dilation	0.0625 mm
20	Effective reduction in clearance due to differential thermal expansion of rotor-stator for transient operation	0.25 mm
21	Total duration of transient operation for transient wear estimation	1000 hours
22	Radial clearance and dimensions of front and backing plate	To be decided by vendor however the minimum radial clearance shall not be less than 2mm to prevent hard rubbing considering maximum distortion of casing and maximum rotor transient excursion
23	No. of Rows of brush seal	1
24	Bristle wire diameter and packing density	To be decided by vendor, based on bristle stability and wear and to be mentioned in approval drawing.
25	Seal Radial stiffness	To be provided by vendor and approved by BHEL
26	Machining details of Stator for brush seal assembly	To be provided by vendor

SKETCH OF BRUSH SEAL MEAN DIA. 1175 FOR VARIANT 02:

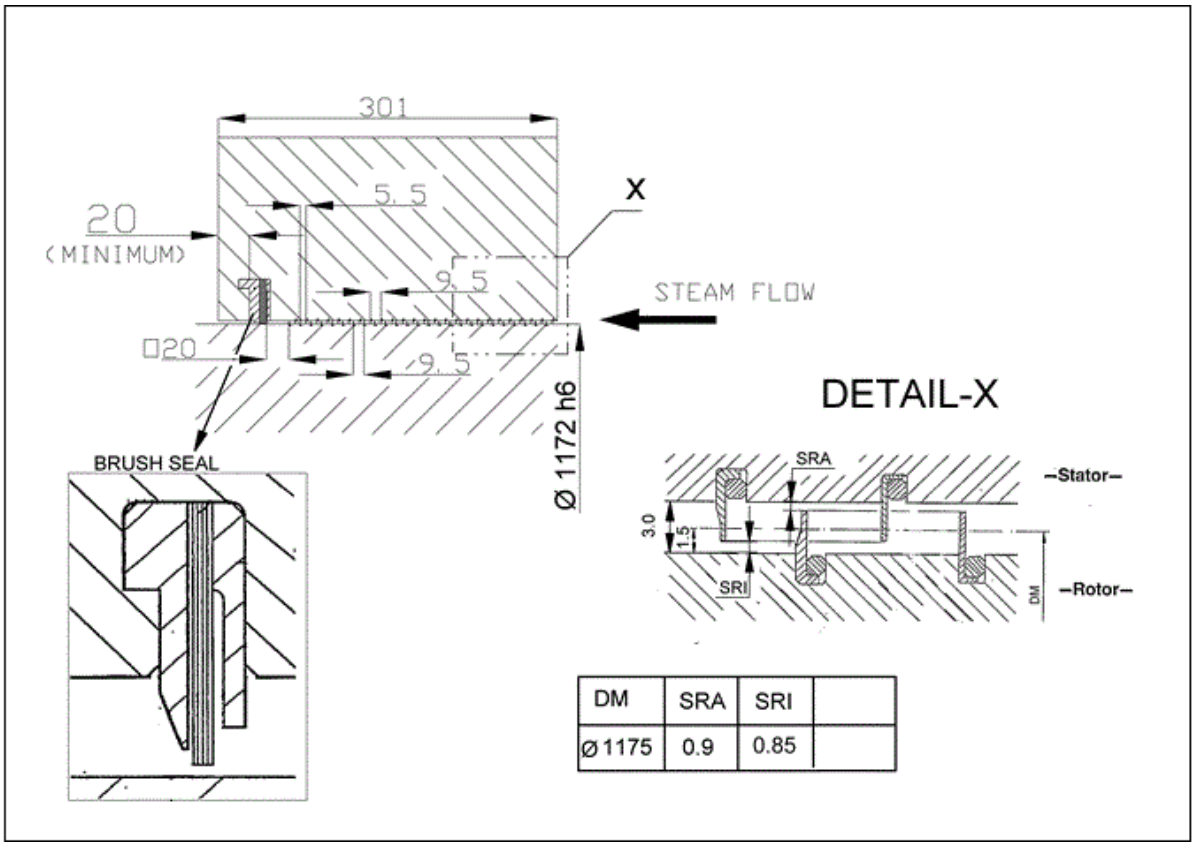

Fig.2

REF DOC

ANNEXURE - III

Variant: 03

TECHNICAL REQUIREMENT OF BRUSH SEAL MEAN DIA 762 (Refer Fig-3)

1	Design Life	Minimum operating life of the brush seal shall be 5 years assuming 200 start up and shut down cycles per year. The total minimum life is 42500 hours
2	Material	Brush seal (Fig.3) including its components to withstand a temperature of 529 Deg. C (max.). The bristle material shall be preferably Haynes 25 and supplier to furnish the material selected along with offer
3	Shaft Diameter	Dia. 758 h9 mm (Base Diameter) Dia. 762 (mean Dia. Of gland)
4	Total Length of Steam Gland (Stator)	280.0 mm
5	Total No of 'See-through' Labyrinth fins ahead of brush seal	52
6	Pitch of the labyrinth fins on stator	5.7 mm
7	Pitch of the labyrinth fins on rotor	3.35 mm
8	Direction of Rotation of Shaft	Counter-clockwise when seen in the steam flow direction (up-steam to downstream)
9	Rotational speed of Shaft	3000 rpm
10	Material of Shaft	30CrMoNiV511
11	Inlet Pressure/ Temp. (Normal/ Max.) of intermediate gland	102 ata/ 508 Deg. C (Normal) 110 ata/ 516 Deg. C (Max.)
12	Outlet Pressure/ Temp. (Normal/ Max.) of intermediate gland	30.9 ata/ 340 Deg. C (Normal) 33.3 ata/ 348 Deg. C (Max.)
13	Maximum allowable leakage quantity through intermediate gland	3.2 tonne per hour
14	Radial clearance of bristle	To be provided by vendor considering rotor excursion

	packing	and rotor dilation and thermal expansion of brush seal at steady state and to be approved by BHEL
15	Steady state Rotor radial excursion	0.055 mm
16	Steady state Rotor radial dilation due to rotational speed	0.080 mm
17	Bristle wear	Bristle wear shall be estimated by vendor by Considering rotor excursion and rotor dilation and effective rotor-bristle tip clearance in steady as well as transient condition. The guidance for allowable value of the wear shall be taken from the leakage flow through effective Clearance after wear for design life as approved by BHEL
18	Transient Rotor radial excursion (During startup and shutdown)	0.33 mm
19	Transient Rotor radial dilation	0.016 mm
20	Effective reduction in clearance due to differential thermal expansion of rotor-stator for transient operation	0.24 mm
21	Total duration of transient operation for transient wear estimation	1000 hours
22	Radial clearance and dimensions of front and backing plate	To be decided by vendor however the minimum radial clearance shall not be less than 1.5mm to prevent hard rubbing considering maximum distortion of casing and maximum rotor transient excursion
23	No. of Rows of brush seal	To be decided by vendor and to be offered as a set
24	Bristle wire diameter and packing density	To be decided by vendor, based on bristle stability and wear and to be mentioned in approval drawing.
25	Seal Radial stiffness	To be provided by vendor and approved by BHEL
26	Machining details of Stator for brush seal assembly	To be provided by vendor

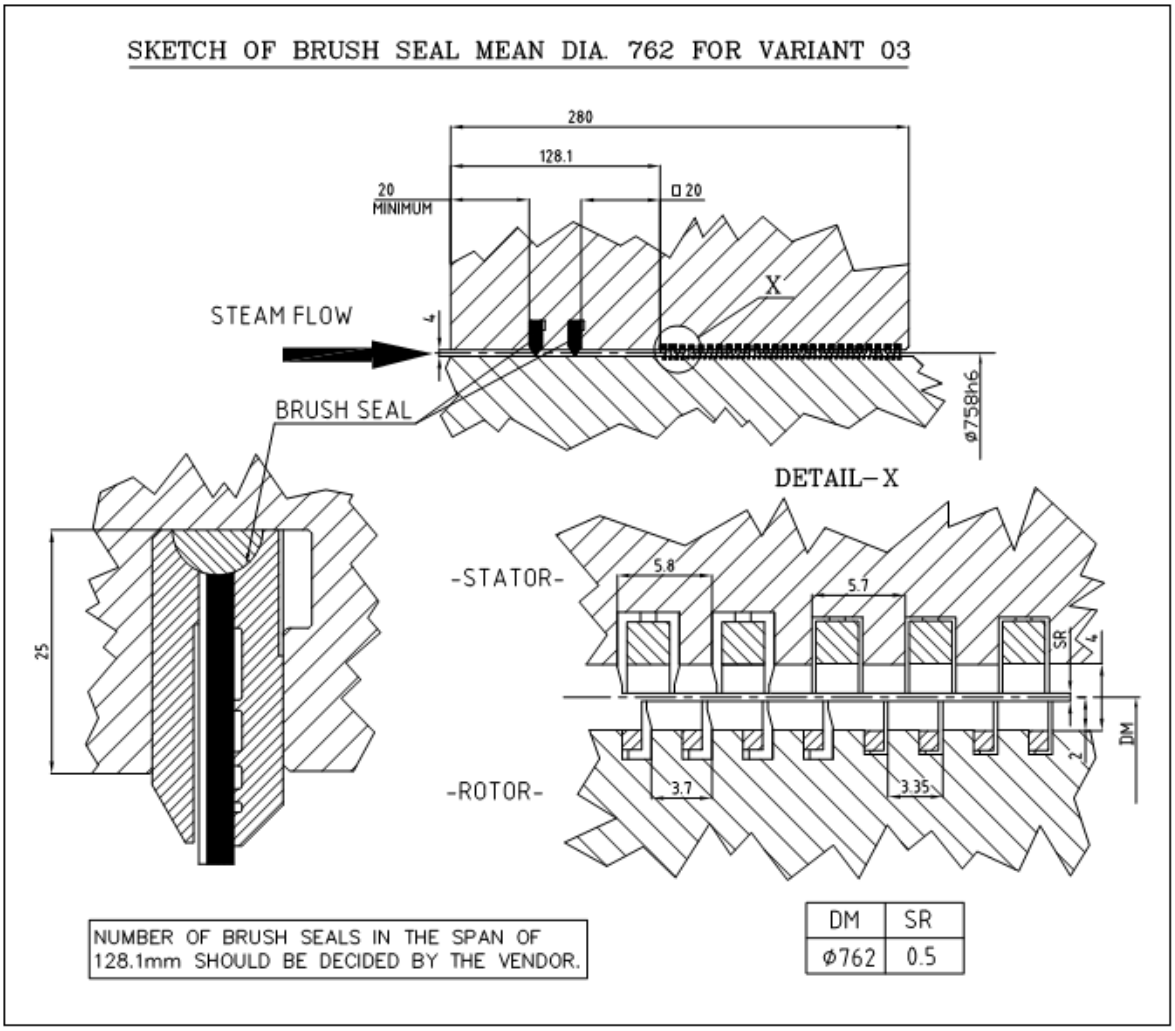

Fig. 3

ANNEXURE - IV

Variant: 04

TECHNICAL REQUIREMENT OF BRUSH SEAL MEAN DIA 1110 (Refer Fig-4)

1	Design Life	Minimum operating life of the brush seal shall be 5 years assuming 200 start up and shut down cycles per year. The total minimum life is 42500 hours
2	Material	Brush seal (Fig.4) including its components to withstand a temperature of 430 Deg. C (max.). The bristle material shall be preferably Haynes 25 and supplier to furnish the material selected along with offer
3	Shaft Diameter	Dia. 1107 h9 mm (Base Diameter) Dia. 1110 (mean Dia. Of gland)
4	Total Length of Steam Gland (Stator)	245.0 mm
5	Total No of 'See-through' Labyrinth fins ahead of brush seal	18
6	Pitch of the labyrinth fins on stator	10.8 mm
7	Pitch of the labyrinth fins on rotor	10.8 mm
8	Direction of Rotation of Shaft	Clockwise when seen in the steam flow direction (up-steam to downstream)
9	Rotational speed of Shaft	3000 rpm
10	Material of Shaft	30CrMoNiV511
11	Inlet Pressure/ Temp. (Normal/ Max.) of balance piston gland	31.2 ata/ 340 Deg. C (Normal) 37.0 ata/ 360 Deg. C (Max.)
12	Outlet Pressure/ Temp. (Normal/ Max.) of intermediate gland	7.65 ata/ 320 Deg. C (Normal) 9.1 ata/ 335 Deg. C (Max.)
13	Maximum allowable leakage quantity through balance piston gland	1.8 tonne per hour
14	Radial clearance of bristle packing	To be provided by vendor considering rotor excursion and rotor dilation and thermal expansion of brush seal at steady state and to be approved by BHEL

15	Steady state Rotor radial excursion	0.082 mm
16	Steady state Rotor radial dilation due to rotational speed	0.25 mm
17	Bristle wear	Bristle wear shall be estimated by vendor by Considering rotor excursion and rotor dilation and effective rotor-bristle tip clearance in steady as well as transient condition. The guidance for allowable value of the wear shall be taken from the leakage flow through effective Clearance after wear for design life as approved by BHEL
18	Transient Rotor radial excursion (During startup and shutdown)	0.2 mm
19	Transient Rotor radial dilation	0.0625 mm
20	Effective reduction in clearance due to differential thermal expansion of rotor-stator for transient operation	0.25 mm
21	Total duration of transient operation for transient wear estimation	1000 hours
22	Radial clearance and dimensions of front and backing plate	To be decided by vendor however the minimum radial clearance shall not be less than 2mm to prevent hard rubbing considering maximum distortion of casing and maximum rotor transient excursion
23	No. of Rows of brush seal	1
24	Bristle wire diameter and packing density	To be decided by vendor, based on bristle stability and wear and to be mentioned in approval drawing.
25	Seal Radial stiffness	To be provided by vendor and approved by BHEL
26	Machining details of Stator for brush seal assembly	To be provided by vendor

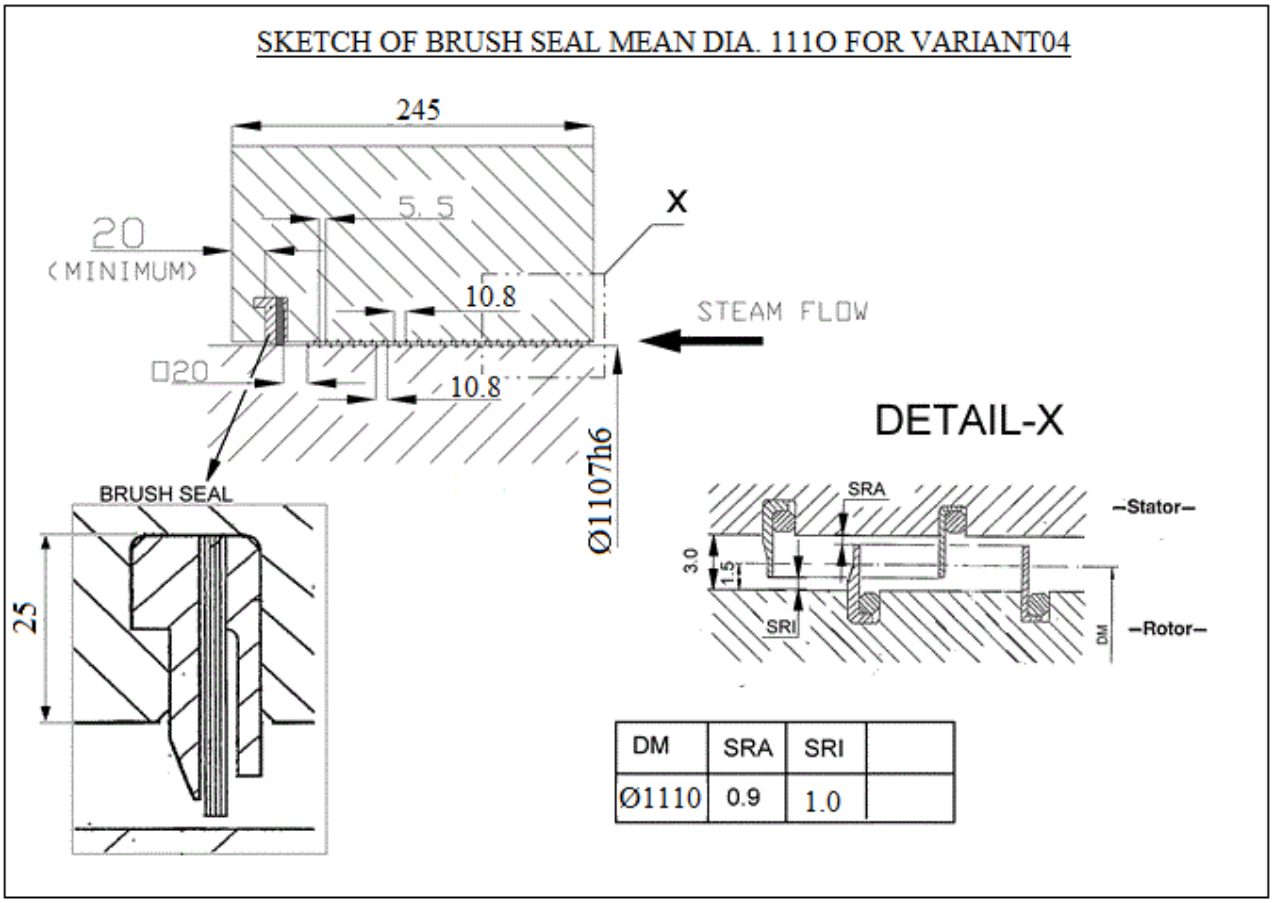

Fig.4

RECORD OF REVISIONS

REV. NO	DATE	REVISION DETAILS	REVISED	APPROVED
00	**23/04/10**	**FIRST ISSUE**	**GMM**	**DSR**
01	**15/12/10**	**Brush seal Dia. Revised Var01: Dia. 725 to 775, Var02: Dia. 1170 to 1175**	**GMM**	**DSR**
02	**23/03/11**	**T.R. Clause 3.22, 3.23, 4.22 modified.**	**GMM**	**DSR**
03	**23/10/13**	**Variants 03 & 04 added.**	**MEERAVALI**	**ASHOK**
04	**21/12/13**	**Leakage qty added for variant 01 & 02.**	**MAMTA**	**GMM**