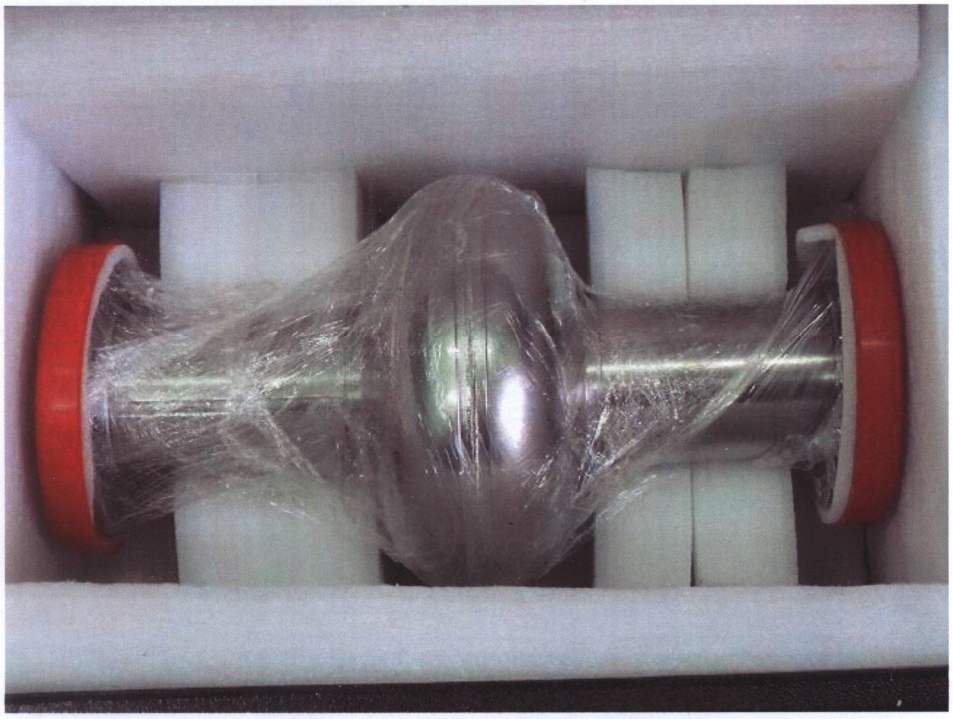
Document Number:
RRCAT/PLSCD/CJQL/SCC/Disp/2011/07

Manufacturing & QA Report of 1.3 GHz Single cell SCRF Cavity

Cavity ID: TE1CAT004



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25/7/11

27/7/11

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Raja Ramanna Centre for Advanced Technology

Introduction:

Raja Ramanna Centre for Advanced Technology (RRCAT) India and Fermi National Accelerator Laboratory (FNAL), USA are members of the institutes working on "Collaboration on R & D for Various Accelerator Physics and High Energy Physics Projects" under the MoU dt January 9, 2006. As per Addendum-I- " Fermi lab RRCAT, BARC, IUAC and VECC Collaboration on ILC Main Linac SRF Accelerator Technology R & D" dated October 2, 2007 to the MoU , RRCAT has taken up development of prototype 1.3 GHz Single cell cavity. Two nos 1.3 GHz prototype single cell cavities have been manufactured in collaboration with IUAC) during 2010. These cavities were processed jointly by FNAL and Argone National Lab (ANL) and tested at 2 K at VTS facility of FNAL.These cavities have achieved E_{acc} of 21 ~ 23 MV/m at Q > 1.5 E+10.

In order to further improve the performance the development of two more single cell cavities has been taken up. Certain modification in process for manufacturing of two improved single cell cavity has been done based on the feedback from the inspection & testing of first two prototypes. First improved single cell cavity dispatched to FNAL in June 2011 for further processing & testing at 2K.Second improved single cell 1.3 GHz cavity (TE1CAT004) has been fabricated in June 2011. This is now being dispatched to Fermi lab for further processing and testing at 2K for cavity performance evaluation.

Present dispatch document comprises of:

1) 1.3 GHz Single cell cavity details
2) Traceability & identification numbering
3) Manufacturing process & modification
4) Various qualification tests performed prior to shipment
5) Drawings
6) Reference

(1) 1.3 GHz Single cell cavity details:

The 1.3 GHz single cell cavity is made based on standard TESLA shape design () provided by FNAL under IIFC collaboration reference to FNAL drawings number: "5520.000-MD-457528-DESY-1.3 GHz TESLA SINGLE CELL RF CAVITY ASSEMBLY, These cavities have been manufactured as per drawings number RRCAT/AAMDD/1.3GHz/SCC/06 – "Cavity Assembly" and inspected as per QA drawing number – "RRCAT/AAMDD/1.3GHz/SCC/QC/06.
These are made with reference to FNAL drawings number: "5520.000-MD-457528-DESY-1.3 GHz TESLA SINGLE CELL RF CAVITY ASSEMBLY.
{Attachment rings have been eliminated from the basic TESLA design based on input from FNAL}.

(2) Traceability & Identification Numbering:

The material used in fabrication of 1.3 GHz Single cell cavity is high RRR niobium sheets 2.8 mm for half cell forming, 3 mm thick welded beam tube and the End Flanges were made from Nb-Ti55% bar stock. All material for manufacturing of cavity is provided by Fermi Lab.

Fig-1 shows the Cavity ID marked at one of the End Flange.
Fig-2 & Fig-3 shows the Half cell ID marked on the Half cell.
LC-FNAL-B3-111-1: LC indicates the shape of the end cell (Long End Cell)- FNAL indicate the source of the material-B3-111-1 indicates the FNAL batch # B3, sheet # 111 & 1 indicates that side 1 is the non RF (outer surface).

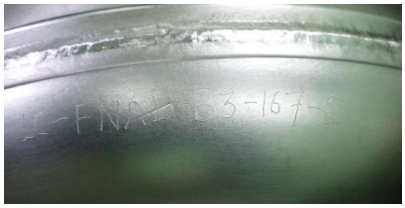
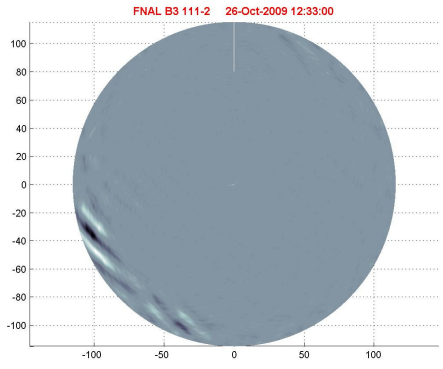


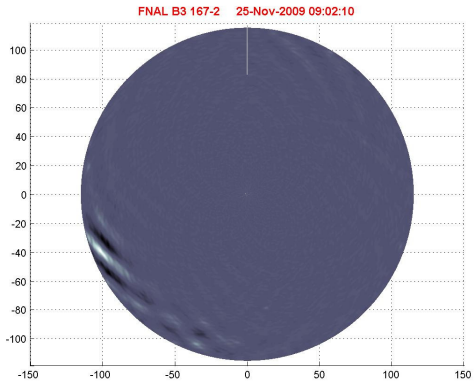
Fig 1: 1.3 GHz Single Cell Cavity ID Fig-2 Half Cell ID, Fig-3 Half cell ID

Table-1 shows the summary of the half cell traceability identification number

	Half-cell 1	Half-cell 2
Sheet number	FNAL-B3-111	FNAL-B3- 167
Outside sheet side (non RF Side)	1	1
Inside sheet side (RF Side)	2	2

Fig-4 & Fig-5 shows the eddy current scan of the sheet 111 & 167 respectively.





(B) End Tube:

End tube 1	End tube 2
ETW 5 (Welded from roll sheet)	ETW 6 (Welded from roll sheet)

Fig-7 End tube ID

C) Flange:

End Flange 1	End Flange 2
EF-05 (From the round NbTi rod having Fermi ID number 13069)	EF-06 ((From the round NbTi rod having Fermi ID number 13069)

Fig-8 End tube ID

(3) Manufacturing process & modification:

Forming of half cells was performed on the forming tooling developed at RRCAT. Design & development of various machining & welding fixture and machining of all the components was done at RRCAT. Electron beam welding was performed under the (RRCAT_IUAC) collaboration at the facility of IUAC, New Delhi. Various mechanical inspections, frequency measurement and leak testing are done at RRCAT.

Based on the feedback from the inspection & testing from FNAL on the first two prototype cavities, we have incorporated following modification in fabrication of TE1CAT004 cavity.

(A) 20 μm Bulk BCP at RRCAT in addition to 3 μm pre-weld etch at IUAC, Delhi.
(B) Beam Oscillation in welding and weld parameter optimization for critical equator weld.
(C) Careful handling of Niobium components during manufacturing process.

(4) Various pre-dispatch qualification tests performed prior to shipment:

The completed 1.3 GHz SCRF cavity was subjected to (a) Visual inspection (b) Mechanical inspection, (c) RF measurement at 300 K & 77 K and (d) Vacuum leak qualification also at 300 K & 77 K.

4.1 Visual & Internal bead inspection

The cavity surface was visually checked for surface defects in particular the sealing surface on end flanges and was found to be acceptable. Fig-9 shows one of the end tube showing sealing surfaces. Fig -10 shows mechanical inspection of cavity.

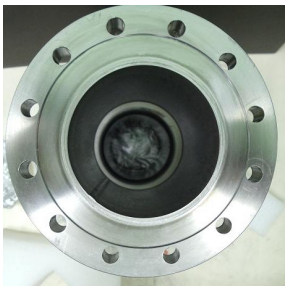


Fig-9: Sealing Surface of Flange

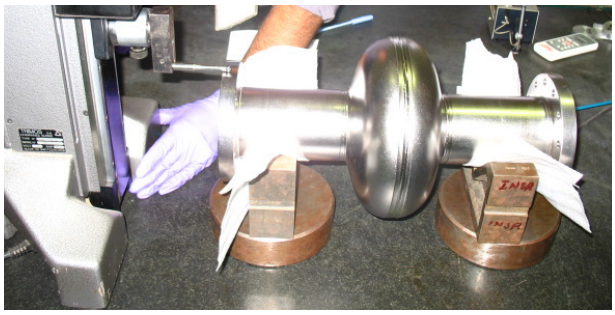


Fig-10 Mechanical Inspection

Visual Check	Visual Requirement	Acceptance Yes/No	Remarks
1	All equator welding seams must be full penetration with no gaps or discontinuities. Under-bead smooth and protrusion relative to surrounding material not to exceed 0.1mm.	Yes	Upper bead is good, under weld bead is good & uniform from 0^{o} to 360^{o}.
2	RF surface (inner surfaces) free of scratch marks	Yes	
3	Sealing surfaces of the End Flange free of damage:	Yes	

4.2 Mechanical Measurements**:**

Assembly ID No. **TE1CAT004** (Half cell ID No. 111 + 167)

Dimension ID	Component	Basic Size	Tolerance	Measured Value	Acceptance Yes/No	Remarks
SCC1	Length	392	±1	390.08	Yes	Under deviation for prototype
SCC2	Parallelism		0.1	0.89	Yes	Under deviation for prototype
SCC3	Perpendicularity		0.1	Not Measured		CMM limitation
SCC4	Concentricity		0.1	0.18	Yes	

4.3 RF Measurements: Table shown the results of Frequency and Q measurements of the final cavity.

Cavity ID	Length (mm)	Frequency (MHz) 300K	Quality factor 300 K	Frequency (MHz) 77K (Vacuum)	Quality factor 77 K
TE1CAT004	390.08	1299.710 MHz	9237	1301.8525 MHz	Not measured

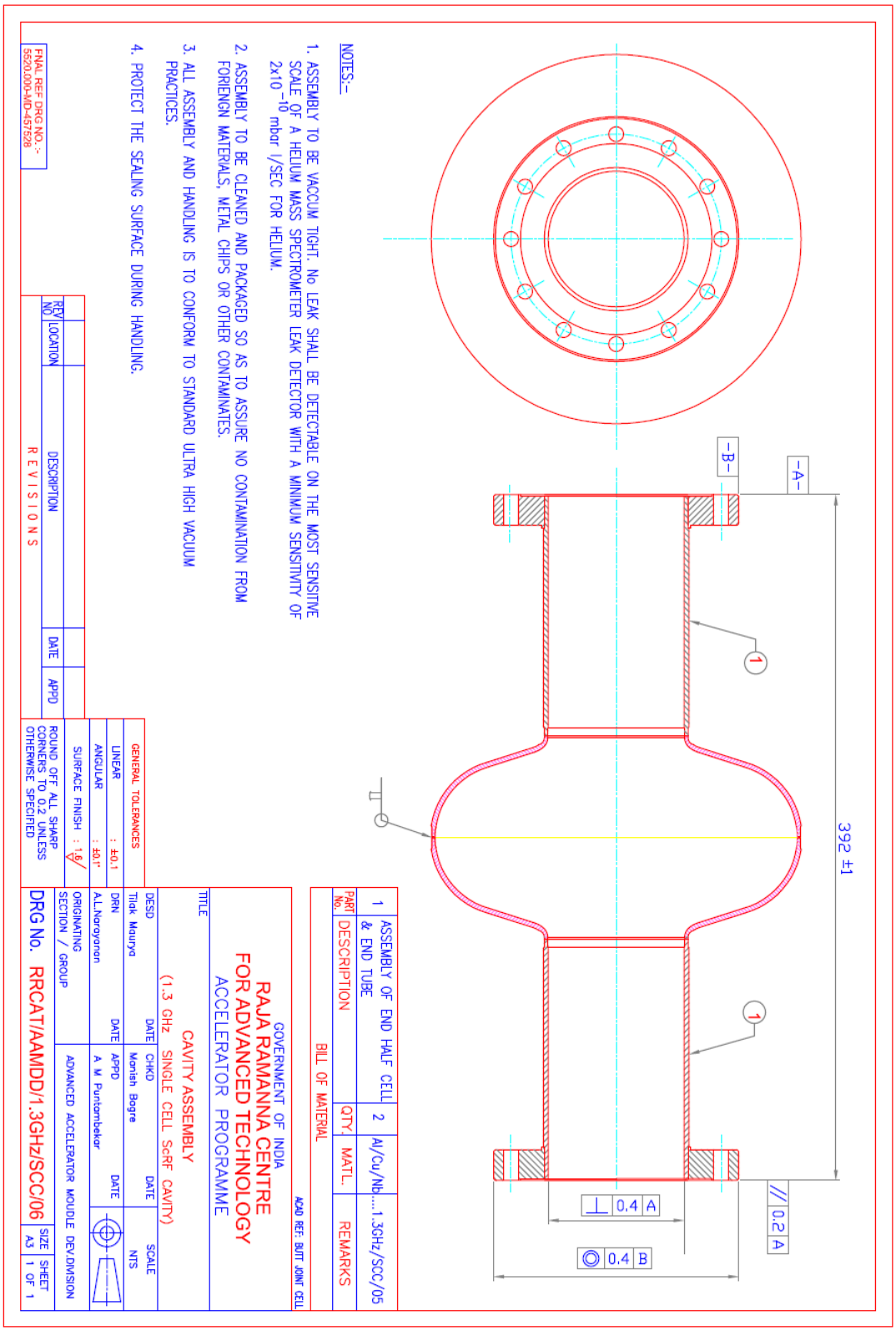
Table-: Frequency Measurement & Q-value.

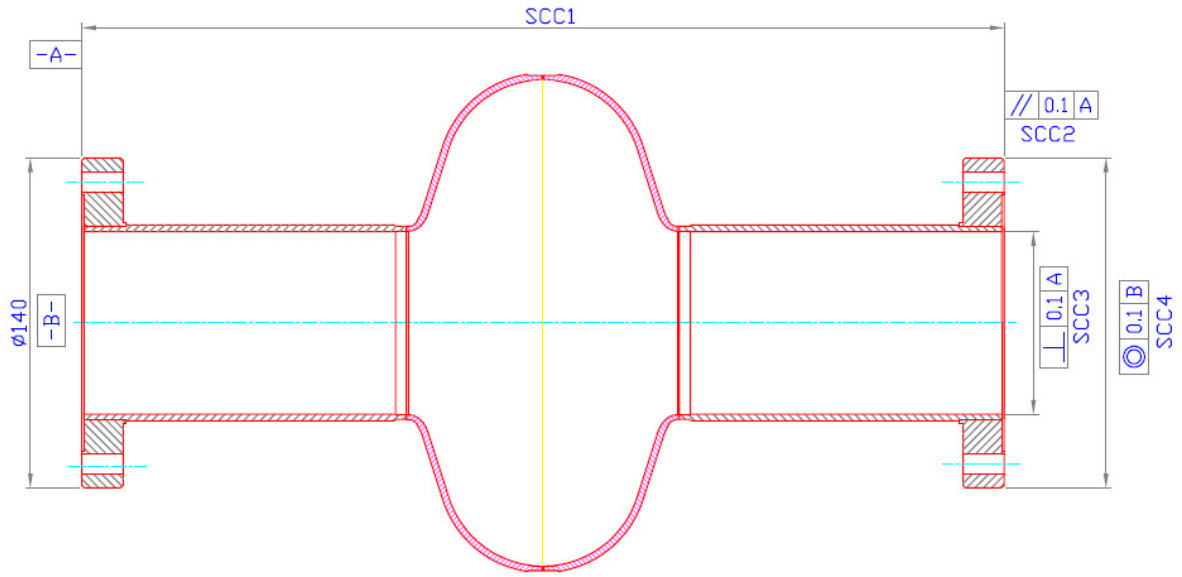
.4: Leak Testing:

The leak testing was performed using HLT 550 Pfeiffer make MSLD set up using Helium as tracer gas.

Test temp	Allowable leak rate	Leak Rate obtained	Acceptance Yes/No	Remarks
300 K	$\leq 10^{-09}$ mbar l/s	$\leq 10^{-12}$ mbar l/s	Yes	
77 K	$\leq 10^{-09}$ mbar l/s	$\leq 10^{-12}$ mbar l/s	Yes	
2 K	$\leq 10^{-09}$ mbar l/s	Not measured	----	

(5) Drawings:


NOTES:-
1. ASSEMBLY TO BE VACCUM TIGHT. No LEAK SHALL BE DETECTABLE ON THE MOST SENSITIVE SCALE OF A HELIUM MASS SPECTROMETER LEAK DETECTOR WITH A MINIMUM SENSITIVITY OF 2x10⁻¹⁰ mbar l/SEC FOR HELIUM.
2. ASSEMBLY TO BE CLEANED AND PACKAGED SO AS TO ASSURE NO CONTAMINATION FROM FORIENGN MATERIALS, METAL CHIPS OR OTHER CONTAMINATES.
3. ALL ASSEMBLY AND HANDLING IS TO CONFORM TO STANDARD ULTRA HIGH VACUUM PRACTICES.
4. PROTECT THE SEALING SURFACE DURING HANDLING.
-A-
-B-
392 ±1
0.4 A
0.4 B
0.2 A
BILL OF MATERIAL
PART NO.
DESCRIPTION
QTY.
MATL.
REMARKS
1
ASSEMBLY OF END HALF CELL & END TUBE
2
Al/Cu/Nb
1.3GHz/SCC/05
ACAD REF: BUTT JOINT CELL
GOVERNMENT OF INDIA
RAJA RAMANNA CENTRE
FOR ADVANCED TECHNOLOGY
ACCELERATOR PROGRAMME
TITLE
CAVITY ASSEMBLY
(1.3 GHz SINGLE CELL ScRF CAVITY)
DESD
Tilak Maurya
DATE
CHKD
Manish Bogre
DATE
APPD
A M Puntambekar
DATE
SCALE
NTS
DRN
A.L.Narayanan
ORIGINATING SECTION / GROUP
ADVANCED ACCELERATOR MOUDLE DEV.DIVISION
DRG No. RRCAT/AAMDD/1.3GHz/SCC/06
SIZE
A3
SHEET
1 OF 1
GENERAL TOLERANCES
LINEAR : ±0.1
ANGULAR : ±0.1°
SURFACE FINISH : 1.6
ROUND OFF ALL SHARP CORNERS TO 0.2 UNLESS OTHERWISE SPECIFIED
FNAL REF DRG NO. :- 5520.000-MD-457528
REVISIONS
REV NO
LOCATION
DESCRIPTION
DATE
APPD



NOTES:-

1. ASSEMBLY TO BE VACCUM TIGHT. No LEAK SHALL BE DETECTABLE ON THE MOST SENSITIVE SCALE OF A HELIUM MASS SPECTROMETER LEAK DETECTOR WITH A MINIMUM SENSITIVITY OF $2x10^{-10}$ mbar l/SEC FOR HELIUMm TO BE TESTED AT ROOM TEMP AND CRYOGENIC TEMP.
2. THE FREQUENCY AND QUALITY FACTOR SHOULD BE MEASURED AT ROOM TEMP AND CRYOGENIC TEMP
3. ASSEMBLY TO BE CLEANED AND PACKAGED SO AS TO ASSURE NO CONTAMINATION FROM FORIENGN MATERIALS, METAL CHIPS OR OTHER CONTAMINATES.
4. ALL ASSEMBLY AND HANDLING IS TO CONFORM TO STANDARD ULTRA HIGH VACUUM PRACTICES.
5. PROTECT THE SEALING SURFACE DURING HANDLING.

GOVERNMENT OF INDIA
RAJA RAMANNA CENTRE
FOR ADVANCED TECHNOLOGY
ACCELERATOR PROGRAMME

TITLE
QUALITY CONTROL DWG FOR CAVITY ASSEMBLY
(1.3 GHz SINGLE CELL ScRF CAVITY)

DESD	DATE	CHKD	DATE	SCALE	
Tilak Maurya		Manish Bagre		NTS	
DRN	DATE	APPD	DATE		
A.L.Narayanan		A M Puntambekar			
ORIGINATING SECTION / GROUP		ADVANCED ACCELERATOR MOUDLE DEV.DIVISION			
DRG No. RRCAT/AAMDD/1.3GHz /SCC/QC/06				SIZE A3	SHEET 1 OF 1

(6) Reference:

[1] DESY- specification of welded 1.3 G Hz Superconducting resonator for TTF-FEL, D. Proch, MHF-SL, 1-1999
[2] 3.9 GHz, 3rd Harmonic SCRF, Fabrication of the Niobium Cavity and End-Groups, FNAL Note 8/3/2005, Don Mitchell, Al Beutler, Mike Foley, Scott Reeves
[3] 1.3 GHz TESLA cavity production and tuning at DESY, G. Kreps , DESY 2006 report
[4} Private Communication with Mike Foley & Timergali Khabiboulline, FNAL.
[5] FNAL reference No. 892851-1-"Procedure for Inter-facility Transport of 1.3 GHz One-cell SRF Cavities"
[6] Dispatch of prototype 1.3 GHz Single-Cell Niobium Cavities to FermiLab under IIFC Collaboration for processing and performance evaluation. Documents Number: RRCAT/LVCDS/CJQL/SCC/Disp/2010/01.
[7] Dispatch of prototype 1.3 GHz Single-Cell Niobium Cavities to FermiLab under IIFC Collaboration for processing and performance evaluation. Documents Number: RRCAT/LVCDS/CJQL/SCC/Disp/2011/04.

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