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the **Large Hadron Collider** project

LHC Project Document No.
LHC-TCDQ-EC-0003 ver 0.2

EDMS Document No.
1167537

Engineering Change requested by (Name & Div./Grp.) :
W. Wetering, B.Goddard TE/ABT

Date: 2012-01-10

Engineering Change Request – Class I

Upgrade of TCDQ Collimator

Brief description of the proposed change(s) :

This ECR includes the following proposed changes in IR6:

- Increased length of the TCDQ collimator system from 6.85 m to 10.40 m.
- Modify the composition of the absorber blocks of the TCDQ.
- Improve the design of the VMTAB large displacement bellows.
- Changed positions of the BPMs in this region.

Equipment concerned :	***Drawings concerned :***	***Documents concerned :***
VMTAB **TCDQ** **BPMSB** **TCSG**	**LHCTCDQL0001** **LHCTCDQL0002** **LHCVMTAB0001**	

PE in charge of the item :	***PE in charge of parent item in PBS :***
W. Weterings TE/ABT	***B. Goddard TE/ABT***

Decision of the Project Engineer :	***Decision of the PLO for Class I changes :***
☐ Rejected. ☐ Accepted by Project Engineer, no impact on other items. *Actions identified by Project Engineer* ☑ Accepted by Project Engineer, but impact on other items. *Comments from other Project Engineers required* *Final decision & actions by Project Management*	☐ Not requested. ☐ Rejected. ☐ Accepted by the Project Leader Office. *Actions identified by Project Leader Office*
Date of Approval :	***Date of Approval :***

Actions to be undertaken :

- Modify the length of the TCDQ, and BPMSB position in IR6 in the LHC Layout.
- Study the integration issues related to this increased length and new BPM positions.
- Study and built VMTAB bellows with an improved the design.
- Include these modifications in the LS1 installation schedule.

Date of Completion :	***Visa of QA Officer :***

Note : when approved, an ***Engineering Change Request*** *becomes an* ***Engineering Change Order/Notification****.*

1. DETAILED DESCRIPTION

by Wim WETERINGS

1.1 INCREASED LENGTH OF THE TCDQ COLLIMATOR SYSTEM

Currently the TCDQ consists of a 2 tank system with a total length 6.85 m, as shown in Figure 1, excluding the VMTAB large displacement bellows. The absorber length is 6.0 m of graphite. This engineering change request proposes to modify this to a 3 tank system with a total length 10.40 m, as shown in Figure 2, with 9.0 m absorber length of carbon-composite.

These modifications will be looked after by the TE-ABT group.

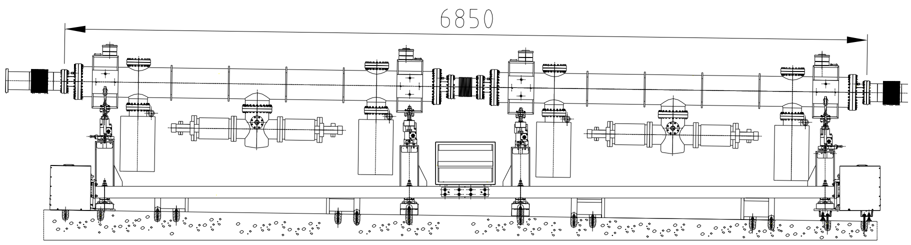

Figure 1 – Current situation of the TCDQ system in 4L6.B2, RA63.

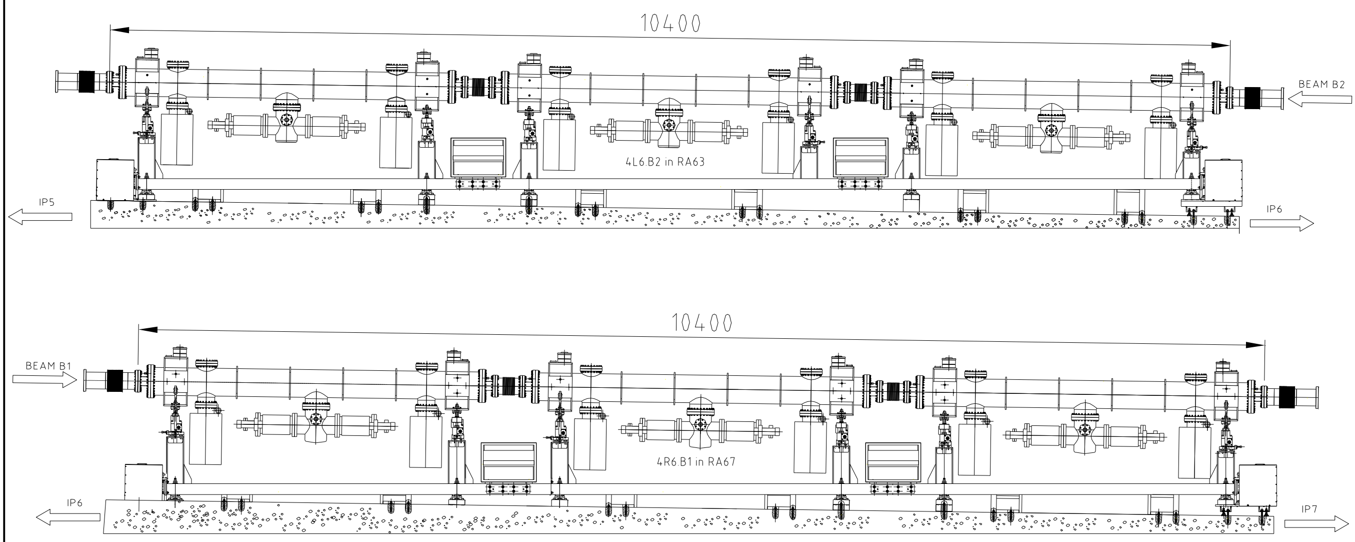

Figure 2 – Proposed layout of the TCDQ system for 4L6.B2 in RA63 (top) and 4R6.B1 in RA67 (bottom).

1.2 NEW COMPOSITION OF TCDQ COLLIMATOR SYSTEM

The newly installed tanks will need to have a modified composition of the internal absorber blocks in order to prevent damage to the absorber and to have improved protection of Q4 in the event of unsynchronised beam dumps. Simulations of the possible damage to the existing system and of possible solutions for the new composition of the internal absorber blocks are ongoing since 2009. In order to be in time for LS1 installation, the final results of these FLUKA and thermo-mechanical simulations shall be available by 03/2012.

1.3 IMPROVE THE DESIGN OF VMTAB BELLOWS

It is also planned to build and install new VMTAB bellows with an improved design which have less friction during operation and do not have the operational problem of bulging contact fingers as observed in the current design. This will reduce wear on mechanical components, improve positioning accuracy, reduce risk of a vacuum leak and reduce the risk of an aperture limitation for the circulating or extracted beam.

Since the expertise of bellow design is not within the TE-ABT group, it is proposed that these modifications will be looked after by the TE-VSC group.

1.4 GIRDER MOTORISATION

The current TCDQ girder motorisation and control system is based on a closed loop cycle using potential-meters controlling the displacement of DC motors with a LDVT for redundancy. There have been discussions to change this system to an open loop cycle based on the PXI platform with stepping motors, as for LHC collimator system, but these changes are not proposed in this ECR.

The current motorisation systems have a positioning accuracy of ± XXmm at each extremity of the TCDQ absorber. Since we propose to maintain the same system, identical positioning accuracy can be obtained.

2. REASONS FOR CHANGE

by Brennan GODDARD, Wim WETERINGS

2.1 INCREASED LENGTH OF THE TCDQ COLLIMATOR SYSTEM

Currently the 6.85 m long TCDQ system houses a 6 m long graphite absorber structure. Simulations of possible fault cases and the related damage that could occur to the TCDQ have shown that an asynchronous dump of a 7 TeV nominal beam could damage the TCDQ blocks [1]. For this reason, the absorber material needs to be changed to a lower density carbon composite, to reduce energy deposition and improve mechanical strength. To maintain the protection for the downstream Q4, the absorber length therefore needs to increase.

In addition, separate studies have shown that the full LHC beam impacting in one spot could tunnel through 25-30 m of higher density material e.g. copper, but that the beam should not tunnel through a graphite absorber of about 10 m length [1].

As a result a 3 tank, 9 meter long, carbon fibre reinforced graphite absorber structure is proposed, rather than the currently installed 6 meter long graphite structure, to avoid damage to the TCDQ in the event of an asynchronous dump, and also to reduce considerably the damage to the downstream LHC equipment in case of an uncontrolled beam loss on the TCDQ.

2.2 IMPROVE THE DESIGN OF VMTAB BELLOWS

The TCDQ system is connected to the vacuum chambers by 2 VMTAB bellows, which include impedance shielding and allow a displacement of ±20 mm, as illustrated in Figure 3. These bellows also function as transition from the TCDQ racetrack shaped aperture to the 110 mm circular aperture of the LHC vacuum chambers. To allow the required ±20 mm movement of the TCDQ girder, long RF contact fingers have been used to assure proper impedance shielding. However, due to the stretched length, these fingers have shown to be prone to bulge out during installation or operation, see Figure 4. It is recommended to build and install new bellows with an improved design to avoid this problem in the future, while at the same time reducing the present large force needed to offset the bellows.

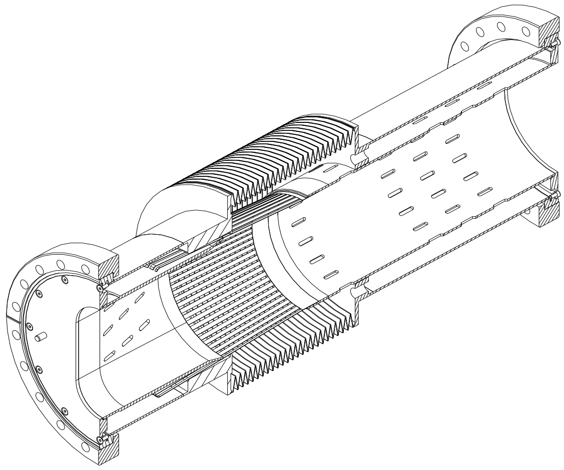

Figure 3 – Section through the VMTAB bellows showing the racetrack to circular transition and RF contact fingers.

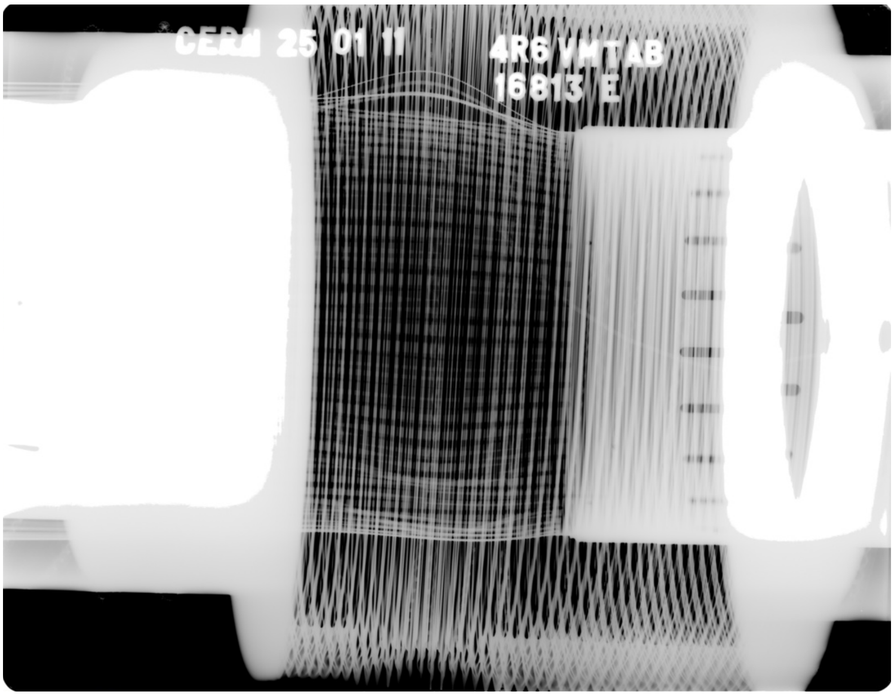

Figure 4 – Image of installed VMTAB bellow in 4R6, showing problem with bulged out contact fingers.

1. IMPACT ON COST, SCHEDULE & PERFORMANCE **by Jan BORBURGH**

1.1 COST

The projected modifications, with the exception of the VMTAB bellow design, will be planned by the TE-ABT group. Initially for 2011 a budget of 80 kCHF was allocated to replace the absorbing blocks only (budget code 65843). However, in order to complete the entire modification, a material budget of 450 kCHF needs to be allocated over the years 2012 and 2013.

1.2 SCHEDULE

The personnel estimate of 3 MY is foreseen within the ABT group for tasks scheduled for LS1.

The proposed modification of the TCDQ system has not yet been scheduled and should be included in the LS1 installation planning.

1.3 PERFORMANCE

The impact on the performance of the system is as described in paragraph 2.

2. IMPACT ON OTHER ITEMS

by Wim WETERINGS

2.1 BEAM POSITIONING MONITORS – BPMSA, BPMSB

It is proposed to extend the TCDQ structure in upstream direction. Depending on the outcome of the integration studies, the BPMSA and BPMSB monitors have to be moved in order to create space for the extended length of the TCDQ system, as shown in Figure 5. The work related to this change (integration, mechanical arrangement and cabling) must be evaluated. Nevertheless, the impact should remain small since a change of BPM aperture will not be necessary and limited to moving and re-cabling of the systems.

2.2 COLLIMATOR - TCSG

Depending on the outcome of the integration studies, the TCSG collimator possibly has to be moved in order to create space for the extended length of the TCDQ system, as shown in Figure 5. It should be noted that this will be avoided if possible, since it is proposed to extend the TCDQ structure in upstream direction.

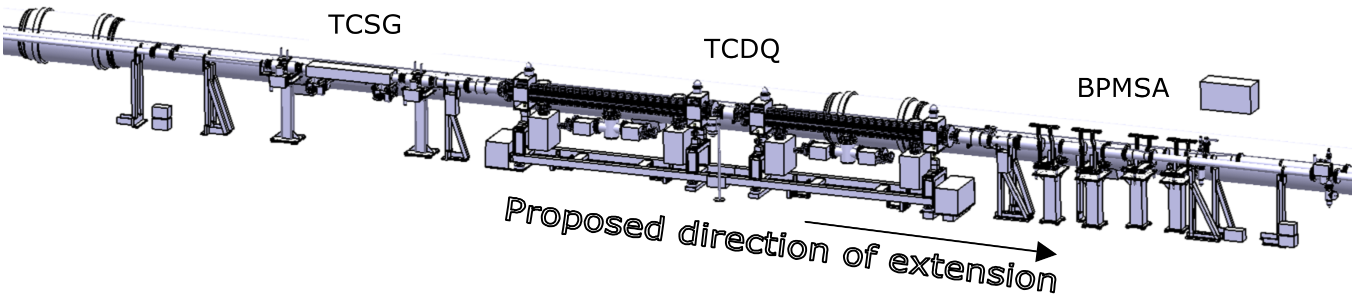

Figure 5 – Integration of the current TCDQ situation in 4L6, showing the possible impact on the BPMSB and TCSG positions. The mirror image applies in 4R6.

2.3 THERMOMECHANICAL SIMULATIONS

In order to propose and validate a new composition of the internal absorber blocks, the simulations of the possible damage to the existing system and of possible solutions for the new composition need to be completed. In order to be in time for LS1 installation, the final results of FLUKA and thermo-mechanical simulations shall be available by 03/2012.

2.4 IMPEDANCE

The estimated [2] power deposited by the circulating beam due to EM losses, in the TCDQ absorber blocks, with a 5 μm copper coating, will be about 2.5 W/m or ~15 W in total. (In case no copper coating is applied, the estimated power deposition will be about 160 W/m or ~ 960 W in total). Considering these values, after the upgrade, the estimated power deposited by the circulating beam will be about ~23W.

2.5 COOLING REQUIREMENTS

The installed TCDQ tanks, 2 on each side of IP6 connected in series, are currently water cooled with a flow of ~5 l/min. The specified required maximum cooling capacity is 7.5 l/min and after the upgrade the same specification of 7.5 l/min will be required.

2.6 INTEGRATION

The integration team has been involved in the study of the new TCDQ but with the other integration projects in process and by lack of time this job did not complete. The integration study should be continued and finished by 03/2012.

2.7 CONTROLS ISSUES

Implication for the control section will mainly consist of:

- Moving and re-cabling the motorisation system;
- Adaptation of the control interface from 2 to 3 tanks;
- Moving and re-cabling the cooling system.

2.8 VACUUM SYSTEM

There are several impacts on the vacuum system and consist of:

Vacuum Layout

The vacuum layout needs to be re-designed following the integration studies. The current and approximate projected layout for 4L6 and 4R6 are given in Appendix 1 as follows:

Table 1: Vacuum layout of 4L6.B2 in RA63 before upgrade.

Table 2: Projected vacuum layout of 4L6.B2 in RA63 after upgrade.

Table 3: Vacuum layout of 4L6.B1 in RA63 before upgrade.

Table 4: Projected vacuum layout of 4L6.B1 in RA63 after upgrade.

Table 5: Vacuum layout of 4R6.B2 in RA67 before upgrade.

Table 6: Projected vacuum layout of 4R6.B2 in RA67 after upgrade.

Table 7: Vacuum layout of 4R6.B1 in RA67 before upgrade.

Table 8: Projected vacuum layout of 4R6.B1 in RA67 after upgrade

Bellows

As described in section 1.3, it is recommended to build and install new VMTAB bellows with an improved design. Furthermore, additional VMZAS need to be build and installed.

Vacuum Tanks

Two additional tanks will be build and need to be validated before installation. These tank stall be equipped with:

- *Heating Jackets*

  The tanks shall be equipped with heating jackets. The current design of the heating jackets has some interference or near contact with the adjacent vacuum chamber. Following the integration studies, the heating jacket design could be improved. For information, see drawing LHCTCDQV0013.
- *Ion pumps*

  Each tanks shall be equipped with 2 ion pumps. The installed tanks are currently equipped with 2 triode vacuum pumps, model 912-7022. For information, see drawings LHCTCDQV0001, LHCTCDQV0008.
- *Sublimators*

  Each tanks shall be equipped with 2 sublimators. For information, see drawings LHCTCDQV0001, LHCTCDQV0008.

3. CHANGE CLASS

by Wim WETERINGS

The proposed changes are of CHANGE CLASS I.

4. COMMENTS

by TCDQ Project engineer

5. COMMENTS

by BPMSA Project Engineer

6. COMMENTS

by TCSG Project Engineer

7. COMMENTS

by Integration & Coordination

8. COMMENTS

by Vacuum Group

9. REFERENCES

[1] TCDQ Upgrade Meetings & Presentations, https://edms.cern.ch/nav/P:CERN-0000076426:V0/P:CERN-0000085158:V0/

[2] LHC-TCDQ-ES-0001, EDMS 503490

10. APPENDIX 1

Table 1: Vacuum layout of 4L6.B2 in RA63 before upgrade.

DCUM	SUBSECTOR	SLOT_ID	FROM_IP	LENGTH	S_START	S_END	NAME	STATUS
16506.812		377627	-154.99	1.48	16506.812	16508.292	TCSG.4L6.B2	INSTALLED
16508.292	VACSEC.A4L6.R	847710	-153.51	0.52	16508.292	16508.812	VAMTA.A4L6.R	INSTALLED
16508.812	VACSEC.A4L6.R	847709	-152.99	0.5	16508.812	16509.312	VCTEA.4L6.R	INSTALLED
16509.312	VACSEC.A4L6.R	847708	-152.49	0.5	16509.312	16509.812	VMTAB.B4L6.R	INSTALLED
16509.512								
16509.812		103278	-151.99	3.3	16509.812	16513.112	TCDQD.4L6.B2	INSTALLED
16513.112	VACSEC.A4L6.R	847707	-148.69	0.25	16513.112	16513.362	VMZAS.4L6.R	INSTALLED
16513.362		616959	-148.44	3.3	16513.362	16516.662	TCDQU.4L6.B2	INSTALLED
16516.662	VACSEC.A4L6.R	847706	-145.14	0.5	16516.662	16517.162	VMTAB.A4L6.R	INSTALLED
16516.812								
16517.112								
16517.162	VACSEC.A4L6.R	847705	-144.64	0.4	16517.162	16517.562	VCTCS.4L6.R	INSTALLED
16517.562	VACSEC.A4L6.R	847704	-144.24	0.35	16517.562	16517.912	VMZAH.C4L6.R	INSTALLED
16517.912		377628	-143.89	0.285	16517.912	16518.197	BPMSB.B4L6.B2	INSTALLED
16518.197	VACSEC.A4L6.R	847703	-143.605	0.35	16518.197	16518.547	VMZAH.B4L6.R	INSTALLED
16518.547		377629	-143.255	0.285	16518.547	16518.832	BPMSB.A4L6.B2	INSTALLED
16518.832	VACSEC.A4L6.R	847702	-142.97	0.35	16518.832	16519.182	VMZAH.A4L6.R	INSTALLED
16519.132								
16519.182	VACSEC.A4L6.R	847568	-142.62	0.4	16519.182	16519.582	VCTCA.4L6.R	INSTALLED
16519.417								
16519.582	VACSEC.A4L6.R	847701	-142.22	2.422	16519.582	16522.004	VCDVC.4L6.R	INSTALLED
16519.717								
16520.002								

Table 2: Projected vacuum layout of 4L6.B2 in RA63 after upgrade.

DCUM	SUBSECTOR	SLOT_ID	FROM_IP	LENGTH	S_START	S_END	NAME	STATUS
16506.812		377627	-154.99	1.48	16506.812	16508.292	TCSG.4L6.B2	INSTALLED
16508.292	VACSEC.A4L6.R	847710	-153.51	0.52	16508.292	16508.812	VAMTA.A4L6.R	INSTALLED
16508.812	VACSEC.A4L6.R	847709	-152.99	0.5	16508.812	16509.312	VCTEA.4L6.R	INSTALLED
16509.312	VACSEC.A4L6.R	847708	-152.49	0.5	16509.312	16509.812	VMTAB.B4L6.R	NEW
16509.512								
16509.812		103278	-151.99	3.3	16509.812	16513.112	TCDQD.4L6.B2	INSTALLED
16513.112	VACSEC.A4L6.R	847707	-148.69	0.25	16513.112	16513.362	VMZAS.4L6.R	INSTALLED
16513.362			-148.44	3.3	16513.362	16516.662	TCDQC.4L6.B2	NEW
16516.662	VACSEC.A4L6.R		-145.14	0.25	16516.662	16516.912	VMZAS.4L6.R	NEW
16516.912		616959	-144.89	3.3	16516.912	16520.212	TCDQU.4L6.B2	INSTALLED
16520.212	VACSEC.A4L6.R	847706	-141.59	0.5	16520.212	16520.712	VMTAB.A4L6.R	NEW
16520.362								
16520.662								
16520.712	VACSEC.A4L6.R	847705	-141.09	0.4	16520.712	16521.112	VCTCS.4L6.R	INSTALLED
16521.112	VACSEC.A4L6.R	847704	-140.69	0.35	16521.112	16521.462	VMZAH.C4L6.R	INSTALLED
16521.462		377628	-140.34	0.285	16521.462	16521.747	BPMSB.B4L6.B2	INSTALLED
16521.747	VACSEC.A4L6.R	847703	-140.055	0.35	16521.747	16522.097	VMZAH.B4L6.R	INSTALLED
16522.097		377629	-139.705	0.285	16522.097	16522.382	BPMSB.A4L6.B2	INSTALLED
16522.382	VACSEC.A4L6.R	847702	-139.42	0.35	16522.382	16522.732	VMZAH.A4L6.R	INSTALLED
16522.682								
16522.732	VACSEC.A4L6.R	847568	-139.07	0.4	16522.732	16523.132	VCTCA.4L6.R	INSTALLED
16522.967								
16523.132	VACSEC.A4L6.R	847701	-138.67	2.422	16523.132	16525.554	VCDVC.4L6.R	INSTALLED
16523.267								
16523.552								

Table 3: Vacuum layout of 4L6.B1 in RA63 before upgrade.

DCUM	SUBSECTOR	SLOT_ID	FROM_IP	LENGTH	S_START	S_END	NAME	STATUS
16506.812								
16508.292								
16508.812								
16509.312								
16509.512	VACSEC.A4L6.B	847643	-152.29	0.3	16509.512	16509.812	VMAAB.C4L6.B	INSTALLED
16509.812	VACSEC.A4L6.B	847642	-151.99	7	16509.812	16516.812	VCDA.A4L6.B	INSTALLED
16513.112								
16513.362								
16516.662								
16516.812	VACSEC.A4L6.B	847641	-144.99	0.3	16516.812	16517.112	VAMEA.A4L6.B	INSTALLED
16517.112	VACSEC.A4L6.B	847640	-144.69	1.72	16517.112	16518.832	VCDCB.4L6.B	INSTALLED
16517.162								
16517.562								
16517.912								
16518.197								
16518.547								
16518.832	VACSEC.A4L6.B	847639	-142.97	0.3	16518.832	16519.132	VMAAB.B4L6.B	INSTALLED
16519.132		**377630**	**-142.67**	**0.285**	**16519.132**	**16519.417**	**BPMSA.B4L6.B1**	**INSTALLED**
16519.182								
16519.417	VACSEC.A4L6.B	847638	-142.385	0.3	16519.417	16519.717	VMAAB.A4L6.B	INSTALLED
16519.582								
16519.717		**377631**	**-142.085**	**0.285**	**16519.717**	**16520.002**	**BPMSA.A4L6.B1**	**INSTALLED**
16520.002	VACSEC.A4L6.B	847637	-141.8	0.3	16520.002	16520.302	VAMVD.4L6.B	INSTALLED
16520.302	VACSEC.A4L6.B	847636	-141.5	0.5	16520.302	16520.802	VCTCU.4L6.B	INSTALLED
16520.802	VACSEC.A4L6.B	847635	-141	1.258	16520.802	16522.06	VCDIB.4L6.B	INSTALLED

Table 4: Projected vacuum layout of 4L6.B1 in RA63 after upgrade.

DCUM	SUBSECTOR	SLOT_ID	FROM_IP	LENGTH	S_START	S_END	NAME	STATUS
16506.812								
16508.292								
16508.812								
16509.312								
16509.512	VACSEC.A4L6.B	847643	-152.29	0.3	16509.512	16509.812	VMAAB.C4L6.B	INSTALLED
16509.812	VACSEC.A4L6.B	847642	-151.99	10.55	16509.812	16520.362	VCDA.A4L6.B	NEW
16513.112								
16513.362								
16516.662								
16516.912								
16520.212								
16520.362	VACSEC.A4L6.B	847641	-141.44	0.3	16520.362	16520.662	VAMEA.A4L6.B	INSTALLED
16520.662	VACSEC.A4L6.B	847640	-141.14	1.72	16520.662	16522.382	VCDCB.4L6.B	INSTALLED
16520.712								
16521.112								
16521.462								
16521.747								
16522.097								
16522.382	VACSEC.A4L6.B	847639	-139.42	0.3	16522.382	16522.682	VMAAB.B4L6.B	INSTALLED
16522.682		**377630**	**-139.12**	**0.285**	**16522.682**	**16522.967**	**BPMSA.B4L6.B1**	**INSTALLED**
16522.732								
16522.967	VACSEC.A4L6.B	847638	-138.835	0.3	16522.967	16523.267	VMAAB.A4L6.B	INSTALLED
16523.132								
16523.267		**377631**	**-138.535**	**0.285**	**16523.267**	**16523.552**	**BPMSA.A4L6.B1**	**INSTALLED**
16523.552	VACSEC.A4L6.B	847637	-138.25	0.3	16523.552	16523.852	VAMVD.4L6.B	INSTALLED
16523.852	VACSEC.A4L6.B	847636	-137.95	0.5	16523.852	16524.352	VCTCU.4L6.B	INSTALLED
16524.352	VACSEC.A4L6.B	847635	-137.45	1.258	16524.352	16525.61	VCDIB.4L6.B	INSTALLED

Table 5: Vacuum layout of 4R6.B2 in RA67 before upgrade.

DCUM	SUBSECTOR	SLOT_ID	FROM_IP	LENGTH	S_START	S_END	NAME	STATUS
16802.802	VACSEC.A4R6.R	847902	141	0.5	16802.802	16803.302	VCTCU.4R6.R	INSTALLED
16803.302	VACSEC.A4R6.R	847901	141.5	0.3	16803.302	16803.602	VAMEB.4R6.R	INSTALLED
16803.602		377634	141.8	0.285	16803.602	16803.887	BPMSA.A4R6.B2	INSTALLED
16803.887	VACSEC.A4R6.R	847900	142.085	0.3	16803.887	16804.187	VMAAB.A4R6.R	INSTALLED
16804.022								
16804.187		377635	142.385	0.285	16804.187	16804.472	BPMSA.B4R6.B2	INSTALLED
16804.422								
16804.472	VACSEC.A4R6.R	847899	142.67	0.3	16804.472	16804.772	VMAAB.B4R6.R	INSTALLED
16804.772	VACSEC.A4R6.R	847898	142.97	1.72	16804.772	16806.492	VCDCB.4R6.R	INSTALLED
16805.057								
16805.407								
16805.692								
16806.042								
16806.442								
16806.492	VACSEC.A4R6.R	847897	144.69	0.3	16806.492	16806.792	VAMEA.A4R6.R	INSTALLED
16806.792	VACSEC.A4R6.R	847896	144.99	7	16806.792	16813.792	VCDA.A4R6.R	INSTALLED
16806.942								
16810.242								
16810.492								
16813.792	VACSEC.A4R6.R	847895	151.99	0.3	16813.792	16814.092	VMAAB.C4R6.R	INSTALLED
16814.092	VACSEC.A4R6.R	847894	152.29	4.633	16814.092	16818.725	VCDCA.4R6.R	INSTALLED
16814.292								
16814.792								
16815.312								

Table 6: Projected vacuum layout of 4R6.B2 in RA67 after upgrade.

DCUM	SUBSECTOR	SLOT_ID	FROM_IP	LENGTH	S_START	S_END	NAME	STATUS
16802.802	VACSEC.A4R6.R	847902	141	0.5	16802.802	16803.302	VCTCU.4R6.R	INSTALLED
16803.302	VACSEC.A4R6.R	847901	141.5	0.3	16803.302	16803.602	VAMEB.4R6.R	INSTALLED
16803.602		377634	141.8	0.285	16803.602	16803.887	BPMSA.A4R6.B2	INSTALLED
16803.887	VACSEC.A4R6.R	847900	142.085	0.3	16803.887	16804.187	VMAAB.A4R6.R	INSTALLED
16804.022								
16804.187		377635	142.385	0.285	16804.187	16804.472	BPMSA.B4R6.B2	INSTALLED
16804.422								
16804.422	VACSEC.A4R6.R	847899	142.67	0.3	16804.472	16804.772	VMAAB.B4R6.R	INSTALLED
16804.722	VACSEC.A4R6.R	847898	142.97	1.72	16804.772	16806.492	VCDCB.4R6.R	INSTALLED
16805.057								
16805.407								
16805.692								
16806.042								
16806.442								
16806.492	VACSEC.A4R6.R	847897	144.69	0.3	16806.492	16806.792	VAMEA.A4R6.R	INSTALLED
16806.792	VACSEC.A4R6.R	847896	144.99	10.55	16806.792	16817.342	VCDA.A4R6.R	NEW
16806.942								
16810.242								
16810.492								
16813.792								
16814.042								
16817.342	VACSEC.A4R6.R	847895	155.54	0.3	16817.342	16817.642	VMAAB.C4R6.R	INSTALLED
16817.642	VACSEC.A4R6.R	847894	155.84	4.633	16817.642	16822.275	VCDCA.4R6.R	INSTALLED
16817.842								
16818.342								
16818.862								

Table 7: Vacuum layout of 4R6.B1 in RA67 before upgrade.

DCUM	SUBSECTOR	SLOT_ID	FROM_IP	LENGTH	S_START	S_END	NAME	STATUS
16802.802								
16803.302								
16803.602								
16803.887								
16804.022	VACSEC.A4R6.B	864603	142.22	0.4	16804.022	16804.422	VCTCA.4R6.B	INSTALLED
16804.187								
16804.422	VACSEC.A4R6.B	847811	142.62	0.35	16804.422	16804.772	VMZAH.A4R6.B	INSTALLED
16804.472								
16804.772		**377636**	**142.97**	**0.285**	**16804.772**	**16805.057**	**BPMSB.A4R6.B1**	**INSTALLED**
16805.057	VACSEC.A4R6.B	847810	143.255	0.35	16805.057	16805.407	VMZAH.B4R6.B	INSTALLED
16805.407		**377637**	**143.605**	**0.285**	**16805.407**	**16805.692**	**BPMSB.B4R6.B1**	**INSTALLED**
16805.692	VACSEC.A4R6.B	847809	143.89	0.35	16805.692	16806.042	VMZAH.C4R6.B	INSTALLED
16806.042	VACSEC.A4R6.B	847808	144.24	0.4	16806.042	16806.442	VCTCS.4R6.B	INSTALLED
16806.442	VACSEC.A4R6.B	847807	144.64	0.5	16806.442	16806.942	VMTAB.A4R6.B	INSTALLED
16806.492								
16806.792								
16806.942		**103282**	**145.14**	**3.3**	**16806.942**	**16810.242**	**TCDQU.4R6.B1**	**INSTALLED**
16810.242	VACSEC.A4R6.B	847767	148.44	0.25	16810.242	16810.492	VMZAS.4R6.B	INSTALLED
16810.492		**616960**	**148.69**	**3.3**	**16810.492**	**16813.792**	**TCDQD.4R6.B1**	**INSTALLED**
16813.792	VACSEC.A4R6.B	847806	151.99	0.5	16813.792	16814.292	VMTAB.B4R6.B	INSTALLED
16814.092								
16814.292	VACSEC.A4R6.B	847805	152.49	0.5	16814.292	16814.792	VCTEA.4R6.B	INSTALLED
16814.792	VACSEC.A4R6.B	847804	152.99	0.52	16814.792	16815.312	VAMTA.A4R6.B	INSTALLED
16815.312		**377638**	**153.51**	**1.48**	**16815.312**	**16816.792**	**TCSG.4R6.B1**	**INSTALLED**

Table 8: Projected vacuum layout of 4R6.B1 in RA67 after upgrade.

DCUM	SUBSECTOR	SLOT_ID	FROM_IP	LENGTH	S_START	S_END	NAME	STATUS
16802.802								
16803.302								
16803.602								
16803.887								
16804.022	VACSEC.A4R6.B	864603	142.22	0.4	16804.022	16804.422	VCTCA.4R6.B	INSTALLED
16804.187								
16804.422	VACSEC.A4R6.B	847811	142.62	0.35	16804.422	16804.772	VMZAH.A4R6.B	INSTALLED
16804.422								
16804.722		**377636**	**142.97**	**0.285**	**16804.772**	**16805.057**	**BPMSB.A4R6.B1**	**INSTALLED**
16805.057	VACSEC.A4R6.B	847810	143.255	0.35	16805.057	16805.407	VMZAH.B4R6.B	INSTALLED
16805.407		**377637**	**143.605**	**0.285**	**16805.407**	**16805.692**	**BPMSB.B4R6.B1**	**INSTALLED**
16805.692	VACSEC.A4R6.B	847809	143.89	0.35	16805.692	16806.042	VMZAH.C4R6.B	INSTALLED
16806.042	VACSEC.A4R6.B	847808	144.24	0.4	16806.042	16806.442	VCTCS.4R6.B	INSTALLED
16806.442	VACSEC.A4R6.B	847807	144.64	0.5	16806.442	16806.942	VMTAB.A4R6.B	NEW
16806.492								
16806.792								
16806.942		**103282**	**145.14**	**3.3**	**16806.942**	**16810.242**	**TCDQU.4R6.B1**	**INSTALLED**
16810.242	VACSEC.A4R6.B	847767	148.44	0.25	16810.242	16810.492	VMZAS.4R6.B	INSTALLED
16810.492			**148.69**	**3.3**	**16810.492**	**16813.792**	**TCDQC.4R6.B1**	**NEW**
16813.792	VACSEC.A4R6.B		151.99	0.25	16813.792	16814.042	VMZAS.4R6.B	NEW
16814.042		**616960**	**152.24**	**3.3**	**16814.042**	**16817.342**	**TCDQD.4R6.B1**	**INSTALLED**
16817.342	VACSEC.A4R6.B	847806	155.54	0.5	16817.342	16817.842	VMTAB.B4R6.B	NEW
16817.642								
16817.842	VACSEC.A4R6.B	847805	156.04	0.5	16817.842	16818.342	VCTEA.4R6.B	INSTALLED
16818.342	VACSEC.A4R6.B	847804	156.54	0.52	16818.342	16818.862	VAMTA.A4R6.B	INSTALLED
16818.862		**377638**	**157.06**	**1.48**	**16818.862**	**16820.342**	**TCSG.4R6.B1**	**INSTALLED**